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TÜRKİYE
ADDICTION AND ENVIRONMENT
RESEARCH REPORT



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Türkiye Addiction and Environment Research Report

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FOREWORD



Climate change, the depletion of natural resources, and environmental pollution threaten the world we will leave to future generations. One of the often-overlooked causes of these problems is addiction. This is because addictions cause serious harm not only to human health and social life but also to our natural environment.

The process extending from the production to the consumption of addictive substances, and encompassing the natural resources used and the waste generated, leaves behind profound impacts that often go unnoticed. Today, we know that the cost of addiction is borne not only by people but also by our soil, water, forests, and all living organisms. Scientific data reveal the scale of this environmental impact in striking terms. According to World Health Organization data, the tobacco industry causes approximately 80 million tonnes of carbon dioxide emissions each year. This amount is equivalent to the annual emissions of approximately 17 million gasoline-powered vehicles. The fact that approximately 3.2 million hectares of agricultural land worldwide are allocated to tobacco cultivation, and that around 5% of global deforestation is associated with this production, clearly demonstrates the pressure the addiction industry places on our natural environment. Moreover, approximately 3.7 litres of water are used throughout the production and consumption of a single cigarette. Considering that 150.4 billion cigarettes were consumed in Türkiye in 2024 alone, we can better understand the loss of natural resources and the environmental burden behind this consumption. The billions of cigarette butts discarded into the environment each year and the plastic pollution caused by filters further demonstrate that this damage continues even after consumption.

We see a similar picture across other addiction industries. Research shows that between 9 and 22 litres of water may be used to produce one litre of beer, depending on the conditions of the facility. This finding reminds us that the water consumed, energy resources used, and packaging waste generated in the production of addictive products are also significant components of the environmental cost. In synthetic drug production, approximately 25 to 43 kilograms of chemical waste can be generated for every kilogram of substance produced. While our people are losing their health on one hand, natural resources are being wasted and soil and water are being polluted on the other. All of this demonstrates that the fight against addiction is also a fight to protect our natural environment.

> Addiction is **a public health issue** that threatens our future.

The environmental impacts of the digital world cannot be excluded from this broader picture either. According to assessments by the International Energy Agency, global data center electricity consumption reached approximately 485 terawatt-hours in 2025. This figure is expected to double by 2030. Of course, it is not possible to attribute all of this consumption to digital addictions. However, the increase in time spent in digital environments and the intensity of use also affect the energy demand for this infrastructure.

However, the relationship between addiction and the environment is not one-sided. While addiction industries negatively affect nature, environmental problems can also increase people's vulnerability to addiction. Today, approximately 3.6 billion people worldwide live in areas that are highly vulnerable to climate change. Climate-related disasters, economic hardship, forced displacement, and the weakening of social ties can affect individuals' mental health and living conditions, potentially increasing the risk of addiction. Therefore, protecting the environment is also of great importance in supporting people's physical and mental well-being.

As the Turkish Green Crescent Society, we have been working since 1920 to ensure that our people lead healthy, peaceful, and addiction-free lives. Throughout our struggle spanning more than a century, we have always considered individuals together with their families, their environment, and the society in which they live. With the Türkiye Addiction and Environment Research Report, prepared in line with this understanding, we aim to shed light, through scientific data, on the often-overlooked effects of addictions on the environment.

Through this report, we are also presenting the findings of Green Crescent's Research on the Environmental Impact of Psychoactive Substances in Wastewater to the scientific community and the public for the first time. Conducted using samples collected from wastewater treatment plants in seven provinces across Türkiye, this research provides important data for monitoring psychoactive substances and understanding their environmental impacts.

We also consider the COP31 process, which Türkiye will host, an important opportunity to ensure that the multidimensional relationship between addiction and the environment receives greater attention on the international agenda.

We hope that this report will offer a fresh perspective to scientists, policymakers, civil society organisations, and international stakeholders, and help ensure that the environmental impacts of addictions are given greater consideration in public policy.

Assoc. Prof. Dr. Mehmet DİNÇ
President of the
Turkish Green Crescent Society

PREFACE

Climate change, biodiversity loss, environmental pollution, the depletion of natural resources, and the degradation of ecosystems have ceased to be isolated issues. They have become distinct dimensions of global challenges that directly affect human health, social well-being, and sustainable development. In particular, the increasingly visible impacts of climate change make it necessary to assess environmental policies not only in terms of reducing greenhouse gas emissions or transforming energy systems, but also in relation to patterns of production and consumption, public health, the use of natural resources, waste management, and addictions.

The World Health Organization (WHO) regards climate change as a fundamental threat to human health, drawing attention to the increasing scale, frequency, and severity of heatwaves, wildfires, floods, and other extreme weather events. According to WHO data, approximately 3.6 billion people live in areas that are highly vulnerable to climate change. Furthermore, between 2030 and 2050, climate change is estimated to cause approximately 250,000 additional deaths per year from undernutrition, malaria, diarrhoea, and heat stress alone.[1] The WHO states that approximately one in four deaths worldwide is linked to environmental conditions and highlights that environmental risks, particularly those associated with chemicals, waste, and pollution, are among the major determinants of the global burden of disease.[2] These figures demonstrate that environmental protection and the protection of human health cannot be treated as separate policy domains.

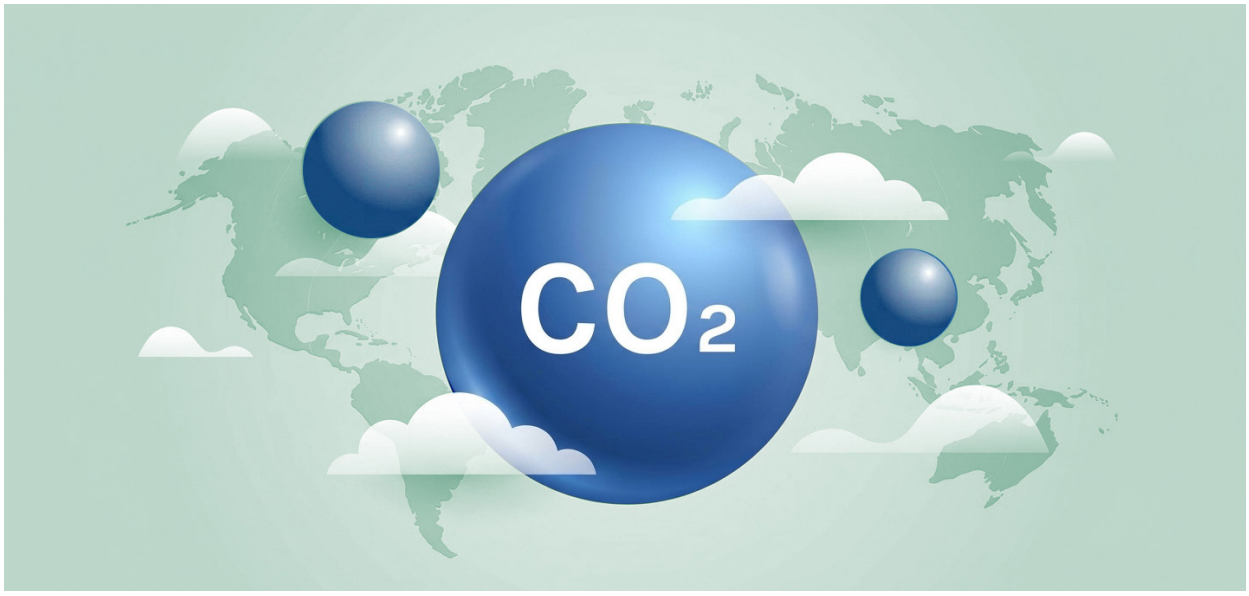
This interdependence has also laid the groundwork for the growing prominence of holistic approaches, such as One Health and planetary health, in global health policies. The WHO defines the One Health approach as an integrated approach that seeks to balance and improve the health of people, animals, plants, and ecosystems by bringing these domains together rather than treating them separately. The close interconnections between human, animal, plant, and environmental health demonstrate that health policies cannot be considered independently of food, water, energy, agriculture, and environmental policies.[3]



1 World Health Organization, "Climate Change," WHO, 12 October 2023, accessed 13 August 2026, https://www.who.int/news-room/fact-sheets/detail/ climate-change-and-health.

2 World Health Organization, "WHO Director-General's Opening Remarks at the Third Session of the Ad Hoc Open-Ended Working Group (OEWG-3) of the Science-Policy Panel on Chemicals, Waste and Prevention of Pollution – 17 June 2024," 17 June 2024, accessed 13 August 2026, https://www.who.int/news-room/speeches/item/who-director-general-s-opening-remarks-at-the-third-session-of-the-ad-hoc-open-ended-working-group-%28oewg-3%29-of-the-science-policy-panel-on-chemicals--waste-and-prevention-of-pollution 17-june-2024

3 World Health Organization, "Estimating Environmental Health Impacts," *WHO*, accessed 13 August 2026, https://www.who.int/activities/environmental-health-impacts



At this point, the relationship between addictions and the environment emerges as an area warranting greater attention at the intersection of public health and environmental policy. Although addictions are most often examined in terms of their physical, psychological, social, and economic consequences for individuals and society, the products and services associated with addictions, as well as the industries that provide them, also have a significant environmental dimension. From the cultivation of agricultural raw materials for tobacco and alcohol products to their production and distribution processes; from the effects of substance production on land use, deforestation, and chemical pollution to the energy, data, and technological infrastructure required by digital platforms and the online gambling ecosystem, this broad range of issues necessitates a more holistic assessment of the environmental consequences of addictions.

Therefore, the environmental impact of addictions is not limited to the waste generated after consumption. When the entire life cycle of products and services is taken into account, a range of environmental impact areas emerge, including agricultural production, land and water use, energy consumption, production facilities, transportation, packaging, digital infrastructure, carbon emissions, chemical pollution, and waste generation.

This framework also makes it possible to approach addiction prevention from a different perspective. While efforts to combat addictions primarily aim to protect the health of individuals and communities, reducing demand for addictive products and services can also be considered an avenue for reducing the environmental burdens associated with their production, distribution, and consumption. In this way, the potential benefits of protective and preventive interventions are not limited to reducing the burden of disease, social costs, or economic losses; they also gain significance in terms of conserving natural resources, reducing waste, and promoting more sustainable ways of living.

The COP Process and Türkiye

One of the most important frameworks for addressing the multidimensional relationship between the environment, climate, and human health at the global level is the Conference of the Parties (COP) process conducted under the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was adopted on 9 May 1992, opened for signature at the United Nations Conference on Environment and Development held in Rio de Janeiro that same year, and entered into force on 21 March 1994.[4] Following the Convention's entry into force, the Conference of the Parties became the principal decision-making mechanism of the international climate regime.

The decisions adopted through the COP process have established the fundamental building blocks of today's international climate regime. One of the first major milestones in this process was the Kyoto Protocol, adopted in

4 United Nations Framework Convention on Climate Change, "United Nations Framework Convention on Climate Change," UNFCCC, accessed 13 August 2026, https://unfccc.int/process-and-meetings/united-nations-framework-convention-on-climate-change.

1997. By introducing binding greenhouse gas emission reduction targets for developed countries and economies in transition, the Protocol ushered in a new era in the fight against climate change. The aggregate targets set for the countries concerned during the first commitment period of the Kyoto Protocol corresponded to an average emissions reduction of 5% below 1990 levels over the 2008–2012 period.[5]

Another fundamental milestone in the global climate regime was the Paris Agreement, adopted in 2015 at COP21, held in Paris. As a legally binding international climate agreement, the Paris Agreement established the central objective of holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C.[6] Under the Paris Agreement, countries set out the actions they will undertake to reduce greenhouse gas emissions and strengthen resilience to the impacts of climate change through their Nationally Determined Contributions (NDCs).[6]

At this stage, COPs have evolved beyond meetings where government delegations negotiate greenhouse gas emission reduction targets into global platforms for discussing a wide range of interconnected issues, including climate finance, adaptation, loss and damage, technology, energy transition, food systems, water, urbanisation, environmental sustainability, and health. This development creates opportunities to explore emerging policy areas at the intersection of environmental sustainability and preventive public health policies.

COP31, which Türkiye will host in Antalya from 9 to 20 November 2026, represents an important opportunity not only for Türkiye's position in global climate diplomacy, but also for bringing the relationships between climate change, environmental sustainability, and public health into greater prominence on the country's policy agenda, and for addressing the relationship between the environment and addiction on both national and international agendas.[7]

The environmental impacts of addiction-related products and services intersect, at various levels, with core concerns of climate and environmental policies, including resource use, production and consumption processes, energy demand, waste generation, pollution, and ecosystem degradation. The impacts arising from the agricultural production and supply chains of tobacco and alcohol products, the consequences of illicit drug production for ecosystems, and the energy and technological infrastructure required by increasingly digitalised forms of addiction represent distinct examples of this intersection.

This intersection also makes it possible to assess the environmental dimensions of Green Crescent's efforts to prevent addictions and foster a culture of healthy living. Although addiction prevention, the strengthening of a culture of healthy living, and the reduction of demand for addictive products and behaviours are primarily aimed at protecting individual and public health, demonstrating the environmental co-benefits of these efforts would help highlight the connections between addiction prevention policies and other policy domains.

Building on this approach, this report aims to examine holistically the relationship between climate change, the environment, healthy living, and addictions. The report will first assess the relationship between climate, the environment, and health, as well as the place of addictions within the perspectives of healthy living and One Health/planetary health. It will then examine the environmental footprint of the tobacco and alcohol industries, drug production, digital addictions, and the gambling industry. The report will also address greenwashing practices within addiction industries, environmental monitoring, the potential of wastewater-based epidemiology for monitoring addictions, and the current situation in Türkiye. The findings of **Green Crescent's Research on the Environmental Impact of Psychoactive Substances in Wastewater**, concerning treatment processes and potential environmental risks, will be shared with the public for the first time. Policy recommendations will be developed in light of these assessments. In this way, the report aims to elucidate the dimensions of addiction prevention that intersect with environmental sustainability and planetary health, and to provide a framework for evidence-based advocacy initiatives that can be advanced during the COP31 process.

5 United Nations Framework Convention on Climate Change, "The Kyoto Protocol," UNFCCC, accessed 13 August 2026, https://unfccc.int/process-and-meetings/the-kyoto-protocol

6 United Nations Framework Convention on Climate Change, "The Paris Agreement," UNFCCC, accessed 13 August 2026, https://unfccc.int/process-and-meetings/the-paris-agreement.

7 United Nations Framework Convention on Climate Change, "UN Climate Change Conference – Antalya, November 2026," *UNFCCC*, accessed 13 August 2026, https://unfccc.int/cop31



CHAPTER 1:
CLIMATE CHANGE AND HEALTHY LIVING

Leading a healthy life depends not only on individual behaviours and access to healthcare services, but also on the conditions of the environment in which people live. Climate change, environmental pollution, and the degradation of natural areas can adversely affect people's living conditions, leading to physical and mental health problems.[1] In its **Global Health Strategy** for 2025–2028, the World Health Organization characterised climate change as an escalating health threat in the 21st century and identified taking action against climate change as the first of its six strategic objectives.[2] In this context, the health impacts of climate change underscore the fact that human health cannot be considered independently of the natural environment and highlight the importance of the planetary health approach. Deteriorating environmental conditions can also influence how individuals cope with difficulties and their health-related behaviours. This makes it necessary to examine the relationship between environmental changes and addictions.

This chapter first explains the relationship between human health and the natural environment through the planetary health approach. It then addresses the health impacts of climate change and environmental changes, addictions in the context of healthy living, and the relationship between climate change and addictions.

1.1. Planetary Health

Although humanity has achieved significant advances over the past century, including increased life expectancy, reduced child mortality, and improvements in healthcare services, these advances have been accompanied by a rapid increase in the use of natural resources and human pressure on the environment. Humanity's economic and social development depends on the resources provided by the atmosphere, oceans, forests, wetlands, and other ecosystems. In turn, the expansion of production, consumption, and energy use has brought about profound changes in the natural systems that sustain human life.[3]

Humanity has achieved economic and social development by meeting its needs for food, water, energy, and raw materials through nature. In this process, living conditions have improved, life expectancy has increased, child mortality has declined, and healthcare services have advanced. However, the expansion of production, consumption, and energy use has led to the increasingly intensive exploitation of natural resources and environmental degradation.[4]

This contradiction between the gains achieved in human health and well-being and the degradation of natural systems has given rise to the planetary health approach. **Planetary health** is defined as the health of human civilisation and the state of the natural systems on which it depends. In a broader sense, this approach requires consideration not only of political, economic, and social conditions necessary to achieve the highest attainable levels of health and well-being worldwide, but also of the boundaries that must not be exceeded if nature is to continue supporting human life. It further emphasises that all societies should benefit equitably from advances in health and well-being.[5] At the core of this approach lies the principle that human health cannot be assessed independently of the state of natural systems.

From a planetary health perspective, climate change, biodiversity loss, and environmental pollution are not merely issues concerning nature. These problems can limit access to clean water and healthy food, affect people's living environments and livelihoods, and increase the risk of disease. For example, while air, water, and soil pollution directly harm human health, they also adversely affect plants, animals, and the natural resources on which people depend. The use of fossil fuels, in turn, causes both air pollution and greenhouse gas emissions that contribute to climate change.[6] Therefore, protecting the environment also means protecting human health.

The causes and consequences of environmental problems are not distributed equally among societies. Low-income and disadvantaged communities, which contribute less to environmental degradation, are often

1 Carlos A. Faerron Guzmán et al., "Planetary Health: Focusing on the Intersection of Human Health and the Earth System," *Annual Review of Environment and Resources* 50 (2025): 303-337; Sarah Whitmee et al., "Safeguarding Human Health in the Anthropocene Epoch: Report of the Rockefeller Foundation–*Lancet* Commission on Planetary Health," *The Lancet* 386, no. 10007 (2015): 1973-2028.

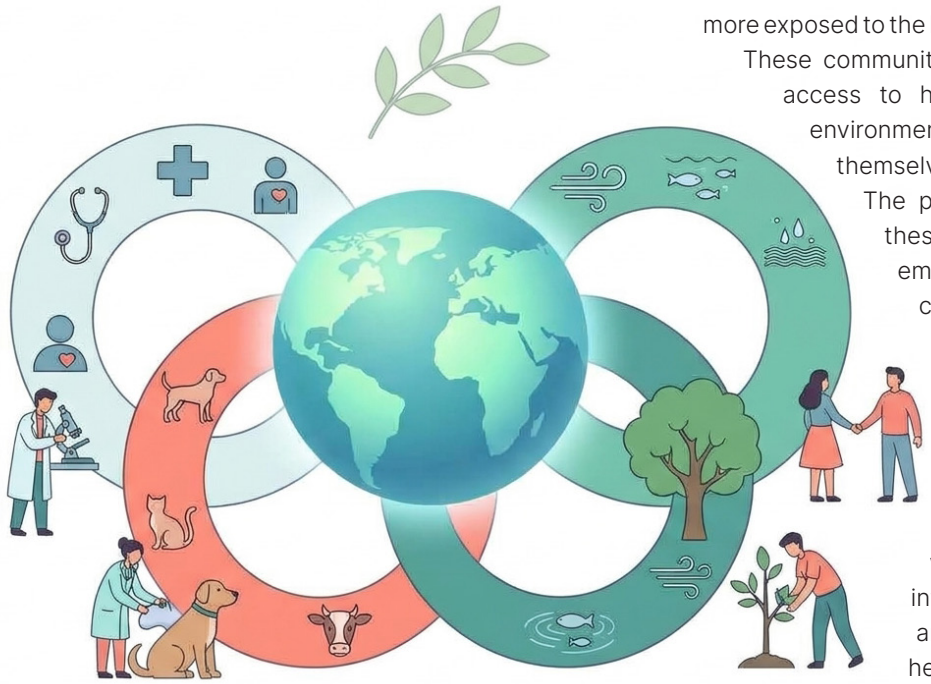
2 *World Health Organization, A Global Health Strategy for 2025–2028: Advancing Equity and Resilience in a Turbulent World: Fourteenth General Programme of Work (Geneva: World Health Organization, 2025), pg. 19, https://www.who.int/about/general-programme-of-work/fourteenth.*

3 Nate Seltenrich, "Down to Earth: The Emerging Field of Planetary Health," *Environmental Health Perspectives* 126, no. 7 (2018): 072001; Whitmee et al., "Safeguarding Human Health."

4 Seltenrich, "Down to Earth"; Whitmee et al., "Safeguarding Human Health."

5 Whitmee et al., "Safeguarding Human Health."

6 Richard Fuller et al., "Pollution and Health: A Progress Update," *The Lancet Planetary Health* 6, no. 6 (2022): e536.



more exposed to the health impacts of these problems. These communities may also have more limited access to healthcare services, safe living environments, and the means to protect themselves from environmental risks.[7] The planetary health approach takes these inequalities into account and emphasises that the environmental costs of current gains in health and well-being should not be transferred to other societies or future generations.[8]

Planetary health shares common ground with the One Health approach, which emphasises the interconnectedness of human, animal, and environmental health. While One Health focuses primarily on health issues arising from interactions between humans, animals, and the environment, planetary health addresses the consequences for human health of broader-scale changes, such as climate change and the degradation of the natural environment. Nevertheless, the scope of both approaches is expanding, and the areas in which they intersect are increasing.[9]

In conclusion, the planetary health approach provides a framework that considers human health inseparable from the natural and social conditions in which people live. Environmental changes can affect human health through the degradation of the natural environment, difficulties in accessing food and clean water, loss of livelihoods, displacement, and social inequalities. These effects are not limited to physical illness. People's mental health, social relationships, and health-related behaviours can also be affected by environmental changes.[10] Therefore, the direct and indirect effects of climate change and environmental changes on health warrant further examination.

1.2. The Relationship Between Climate, the Environment, and Health

The health impacts of climate change and environmental changes arise through various environmental hazards and exposure pathways. Extreme temperatures, floods, storms, and wildfires can directly cause injury, illness, and death in certain circumstances, while deteriorating air and water quality, disruptions to food production and access, changes in ecosystems, and shifts in the distribution of disease-carrying organisms can have more indirect effects on health.[11]

Therefore, when assessing the relationship between climate, the environment, and health, it is necessary to consider not only the resulting health problems, but also the environmental changes that give rise to these problems and the pathways through which these changes affect health. In the planetary health literature, these impacts are generally classified under three categories: *direct impacts, impacts mediated through ecosystems, and indirect, delayed, or geographically displaced impacts.*[12] Direct impacts include heatwaves, floods, water

7 Faerron Guzmán et al., "Planetary Health."

8 Whitmee et al., "Safeguarding Human Health."

9 Faerron Guzmán et al., "Planetary Health"; Rafael Ruiz de Castañeda et al., "One Health and Planetary Health Research: Leveraging Differences to Grow Together," *The Lancet Planetary Health* 7, no. 2 (2023): e109–e111.

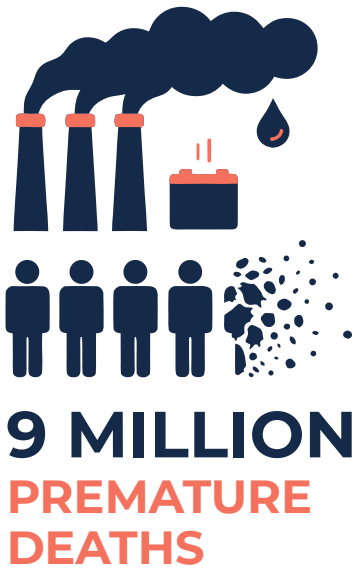
10 Faerron Guzmán et al., "Planetary Health"; Whitmee et al., "Safeguarding Human Health."

11 Emine Didem Evci Kiraz, *İklim Değişikliğinin İnsan Sağlığına Etkileri*, İklim Değişikliği Eğitim Modülleri Serisi 14 (Ankara, 2019), http://profedidemevcikiraz.com/Content/uploads/docs/seri_14.pdf; Faerron Guzmán et al., "Planetary Health"; World Health Organization, *Mapping Climate Change and Health Indicators* (Geneva: World Health Organization, 2025), https://www.who.int/publications/i/item/9789240112346

12 Whitmee et al., "Safeguarding Human Health."

scarcity, landslides, and exposure to ultraviolet radiation and pollutants. Impacts mediated through ecosystems encompass changes in infectious disease risks, malnutrition resulting from reduced food production, the depletion of natural sources of medicines, and anxiety, depression, and other mental health problems associated with the degradation of the living environment. Environmental changes can also trigger social processes such as loss of livelihoods, conflict, and the forced displacement of people from their homes. These processes can lead to the emergence or exacerbation of various health problems, ranging from malnutrition and infectious diseases to depression and post-traumatic stress disorder.[13]

Climate change and environmental changes can affect physical health through various pathways. While deteriorating air quality is associated with respiratory and cardiovascular diseases, contaminated or inadequate water supplies can increase the risk of waterborne diseases such as diarrhoea. Exposure to lead and other toxic substances can adversely affect the nervous system, kidneys, and cardiovascular health. In addition, extreme temperatures increase the risk of heat-related illness and death; disruptions to food production make access to adequate and healthy food more difficult; and changes in temperature and precipitation patterns can alter the geographical distribution and periods of activity of disease-carrying organisms, such as mosquitoes and ticks.[14] The magnitude of the health impacts associated with these diverse environmental exposures is also reflected in estimates of premature mortality. According to the Global Burden of Disease Study 2019, air, water, and lead pollution, together with occupational exposure to hazardous substances, were associated with approximately 9 million premature deaths worldwide each year, equivalent to one in every six deaths.[15]



Climate change and environmental changes can also have adverse effects on mental health. In addition to the loss and trauma caused by disasters, prolonged increases in temperature, damage to livelihoods, food and water insecurity, displacement, and anxiety and uncertainty surrounding climate change have been associated with mental health problems.[16] For example, in a study involving 10,000 young people aged 16–25 across ten countries, more than 45% of participants reported that their feelings about climate change adversely affected their daily lives and functioning.[17]

Nevertheless, environmental hazards do not affect all segments of society to the same extent. Age, pre-existing health conditions, geographical location, income and education levels, working conditions, access to healthcare services, and communities' capacity to adapt to changing conditions can determine their vulnerability to environmental risks.[18] For example, children are among the groups particularly vulnerable to climate-related hazards because of their developmental characteristics and their reliance on essential services such as healthcare, nutrition, water, and sanitation. According to UNICEF's 2026 Children's Climate Risk Report, **1.1 billion children worldwide are exposed to at least three different climate hazards**.[19] Age-related vulnerability is also evident in exposure to extreme temperatures. According to data from the Lancet Countdown, an international research collaboration that systematically



13 Whitmee et al., "Safeguarding Human Health."

14 Faerron Guzmán et al., "Planetary Health"; World Health Organization, *Mapping Climate Change and Health Indicators*; United Nations Children's Fund (UNICEF), *Children's Climate Risk Report 2026* (Florence: UNICEF, 2026), https://www.unicef.org/reports/childrens-climate-risk-report-2026.

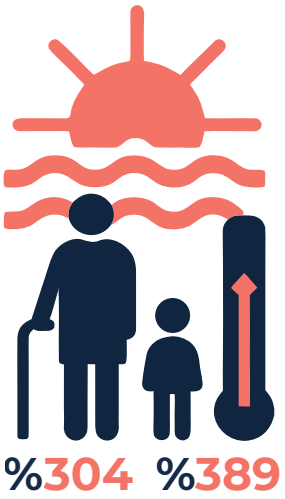
15 Fuller et al., "Pollution and Health."

16 Susan Clayton and Tara Crandon, "Climate Change and Mental Health," *Annual Review of Clinical Psychology*, 21 (2025): 61-83; UNICEF, *Children's Climate Risk Report 2026*.

17 Caroline Hickman et al., "Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey," *The Lancet Planetary Health*, 5, no. 12 (2021): e863-e873.

18 *World Health Organization, Mapping Climate Change and Health Indicators.*

19 *UNICEF, Children's Climate Risk Report 2026.*



monitors the relationship between climate change and health, in 2024, individuals aged over 65 were exposed to **an average of 304% more heatwave days** per person than during the 1986–2005 period, while the increase among children under one year of age **reached 389%**.[20] The greater exposure of low-income and disadvantaged groups to environmental hazards, coupled with their more limited resources to cope with these impacts, can also cause climate change to exacerbate existing health and social inequalities.[21]

In Türkiye, the health impacts of climate change are also becoming increasingly pronounced. The World Health Organization's country profile for Türkiye indicates that temperatures and the number of hot days are increasing, while precipitation patterns are changing. Heat stress, respiratory problems associated with air pollution, and water-, food-, and vector-borne diseases are identified as priority health risks.[22] Türkiye's **Climate Change Adaptation Strategy and Action Plan (2024–2030)** likewise emphasises the significance of hazards such as droughts, heavy precipitation, heatwaves, and strong winds for public health. The plan also highlights the potential impacts of climate change on healthcare facilities, healthcare workers, the continuity of essential services, and the planning of healthcare provision.[23] Therefore, climate change and environmental changes can both give rise to direct health problems and adversely affect healthy living conditions by making access to healthcare services and the continuity of service provision more challenging.[24]

The characteristics of the environments in which people live influence their ability to protect their health and maintain a healthy lifestyle. Access to green spaces, for example, can play a protective role by encouraging physical activity, reducing exposure to environmental hazards such as heat and air pollution, and supporting mental health.[25] In conclusion, climate change and environmental changes can affect physical and mental health, living conditions, social inequalities, and the functioning of healthcare services through interconnected pathways. Accordingly, promoting healthy living should be addressed not only in terms of individual choices and behaviours, but also within the framework of the environmental and social conditions that enable individuals to protect their health. This approach highlights the need to assess behavioural risk factors affecting healthy living, including addictions, in conjunction with environmental and social conditions.

1.3. Addictions from a Healthy Living Perspective

Healthy living is an approach that addresses the protection and promotion of health within the context of daily lifestyle habits and the conditions under which these habits are maintained.[26] This approach encourages healthy lifestyle practices, such as balanced nutrition, regular physical activity, adequate sleep, behaviors that support mental health, and the avoidance of behaviors that may adversely affect health, to become an integral part of everyday life.[27] Health-related behaviors are shaped by various determinants, including individual characteristics, social relationships, education and income levels, working and living conditions, access to healthcare services,

20 Lancet Countdown, "Explore Our Data: Climate Change Impacts, Exposure and Vulnerability," 2025, https://lancetcountdown.org/explore-our-data/.

21 Faerron Guzmán et al., "Planetary Health"; Whitmee et al., "Safeguarding Human Health"; UNICEF, *Children's Climate Risk Report 2026*.

22 World Health Organization, *Türkiye: Health and Climate Change Country Profile 2022* (Geneva: World Health Organization, 2022), https://www.who.int/publications/i/item/WHO-HEP-ECH-CCH-22.01.05.

23 İklim Değişikliği Başkanlığı, *İklim Değişikliğine Uyum Stratejisi ve Eylem Planı* (2024–2030) (Ankara: T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2024, www.iklim.gov.tr/db/turkce/icerikler/files/iklim%20Degisikligine%20Uyum%20Stratejisi%20ve%20Eylem%20Plan.pdf.

24 *UNICEF, Children's Climate Risk Report 2026.*

25 Bo-Yi Yang et al., "Greenspace and Human Health: An Umbrella Review," *The Innovation,* 2, no. 4 (2021): 100164.

26 Mustafa Taşdemir, Abdullah Uçar, Ömer Ataç, Hüseyin Küçükali, and Samet Taşkıran, *Sağlıklı Yaşam*, 2. bs. (İstanbul: Türkiye Yeşilay Cemiyeti, 2023); Silvia Juliana Trujillo-Cáceres et al., "Healthy Living Concepts and Definitions: A Systematic Review with Concept Analysis Proposing a Four-Dimensional Model," Maturitas 210 (2026): 108976.

27 Taşdemir et al., *Sağlıklı Yaşam.*

and the physical environment.[28] To promote healthy living, it is essential to reduce modifiable risk factors and strengthen protective factors among these determinants.[29]

Within this framework, modifiable behavioral risk factors represent an important area for intervention in the prevention of health problems. Tobacco use, harmful alcohol use, physical inactivity, and unhealthy diets are among the major behavioral risk factors for noncommunicable diseases.[30] Among these behaviors, the use of tobacco, alcohol, and other psychoactive substances warrants particular attention, not only because of their direct effects on health but also because of their association with the development of addiction.[31] Addictions can lead to various adverse effects on an individual's health, daily functioning, social relationships, and economic well-being, accompanied by a diminished ability to control substance use or behavior.[32] As these effects extend beyond the individual to their family and wider social environment, addictions must be addressed as a significant public health concern.[33]

Addiction is defined by criteria such as a reduced ability to control substance use or a particular behavior, the increasing priority given to the use or behavior in an individual's life, and its continuation despite negative consequences.[34] In the World Health Organization's *International Classification of Diseases, 11th Revision* (ICD-11), disorders related to addiction are addressed under disorders due to substance use and disorders due to addictive behaviors.[35] Disorders due to substance use arise from the use of alcohol and nicotine, as well as psychoactive substances such as cannabis, cocaine, amphetamines and other stimulants, MDMA, heroin and other opioids, hallucinogens, and synthetic cathinones.[36] Gambling disorder and gaming disorder, in turn, are classified as disorders due to addictive behaviors.[37] While physiological symptoms such as tolerance and withdrawal may also occur in substance addiction, the onset and course of addiction, as well as the health problems it causes, may vary depending on the substance or behavior involved.[38]

Addictions place a significant burden on individuals, societies, and healthcare systems due to their contribution to health problems, premature deaths, social and economic difficulties, and increased demand for healthcare services. Tobacco use is associated with numerous chronic diseases, particularly cancer, cardiovascular diseases, and respiratory diseases.[39] More than 7 million people worldwide die each year as a result of tobacco use and exposure to second-hand smoke. Of these deaths, more than 1.6 million occur among people who do not use tobacco products but are exposed to second-hand smoke.[40] Alcohol use contributes to the development of more than 200 health conditions, including liver and cardiovascular diseases, various types of cancer, mental health problems, and injuries.[41] Approximately 2.6 million deaths were attributable to alcohol use in 2019. Of these deaths, 1.6 million resulted from noncommunicable diseases, 700,000 from injuries, and 300,000 from communicable diseases.[42]

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28 Paula Braveman and Laura Gottlieb, "The Social Determinants of Health: It's Time to Consider the Causes of the Causes," *Public Health Reports* 129, suppl. 2 (2014): 19–31; Lucie Richard, Lise Gauvin, and Kim Raine, "Ecological Models Revisited: Their Uses and Evolution in Health Promotion Over Two Decades," *Annual Review of Public Health* 32 (2011): 307–326; World Health Organization, *World Report on Social Determinants of Health Equity* (Geneva: World Health Organization, 2025), https://www.who.int/publications/i/item/9789240107588.

29 Taşdemir et al., *Sağlıklı Yaşam*.

30 GBD 2021 Risk Factors Collaborators, "Global Burden and Strength of Evidence for 88 Risk Factors in 204 Countries and 811 Subnational Locations, 1990–2021: A Systematic Analysis for the Global Burden of Disease Study 2021," *The Lancet* 403, no. 10440 (2024): 2162–2203; World Health Organization, "Noncommunicable Diseases," September 25, 2025, https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.

31 World Health Organization, Clinical Descriptions and Diagnostic Requirements for ICD-11 Mental, Behavioural and Neurodevelopmental Disorders (CDDR) (Geneva: World Health Organization, 2024), https://www.who.int/publications/i/item/9789240077263.

32 Heather Wardle et al., "The Lancet Public Health Commission on Gambling," *The Lancet Public Health* 9, no. 11 (2024): e950–e994; United Nations Office on Drugs and Crime (UNODC), *World Drug Report 2025: Contemporary Issues on Drugs* (New York: United Nations, 2025), https://www.unodc.org/documents/data-and-analysis/WDR_2025/WDR25_B2_Contemporary_drug_issues.pdf; World Health Organization, *Clinical Descriptions and Diagnostic Requirements for ICD-11*.

33 UNODC, *World Drug Report 2025: Contemporary Issues on Drugs*; Wardle et al., "Lancet Public Health Commission on Gambling."

34 Nora D. Volkow and Carlos Blanco, "Substance Use Disorders: A Comprehensive Update of Classification, Epidemiology, Neurobiology, Clinical Aspects, Treatment and Prevention," *World Psychiatry* 22, no. 2 (2023): 203–229; World Health Organization, *Clinical Descriptions and Diagnostic Requirements for ICD-11*.

35 World Health Organization, Clinical Descriptions and Diagnostic Requirements for ICD-11.

36 European Union Drugs Agency, *European Drug Report 2026: Trends and Developments* (2026), https://doi.org/10.2810/8266522; World Health Organization, *Clinical Descriptions and Diagnostic Requirements for ICD-11*.

37 World Health Organization, Clinical Descriptions and Diagnostic Requirements for ICD-11.

38 Volkow and Blanco, "Substance Use Disorders"; World Health Organization, *Clinical Descriptions and Diagnostic Requirements for ICD-11*.

39 World Health Organization, "Tobacco and Nicotine," June 26, 2026, https://www.who.int/news-room/fact-sheets/detail/tobacco.

40 World Health Organization, "Tobacco and Nicotine."

41 World Health Organization, "Alcohol," June 28, 2024, https://www.who.int/news-room/fact-sheets/detail/alcohol.

42 World Health Organization, "Alcohol."

Drug use is associated with serious health consequences, including mental health problems, infections such as HIV and hepatitis C, drug poisoning due to overdose, and an increased risk of premature death.[43] In 2021, approximately half a million deaths were attributed to drug use, and drug use disorders were reported to have resulted in the loss of 15.6 million healthy life-years.[44] Behavioral addictions can also have significant health consequences. Gambling disorder, in particular, can lead to mental health problems, suicidal behavior, financial difficulties, and problems in interpersonal relationships.[45]

Addictions impose a substantial economic burden due to their effects on health, healthcare expenditure, premature deaths, and productivity losses. In 2022, the global social and economic costs attributable to tobacco use, including healthcare expenditure, premature deaths, and productivity losses, were estimated at approximately USD 1.7 trillion.[46] Studies on alcohol use have also shown that productivity losses account for a substantial proportion of the economic burden, with the total cost corresponding to an average of 1.5% of countries' gross domestic product.[47] In Türkiye, the annual economic cost of tobacco, alcohol, drug use, and gambling has been estimated at approximately USD 78 billion, with a substantial proportion of indirect costs excluded from this calculation.[48] To prevent the health problems caused by addictions and reduce their economic and social costs, the factors contributing to the development of addiction must also be taken into account.

The development of addictions is influenced not only by individual characteristics but also by the social, economic, and physical environments in which individuals live. Environmental factors, such as family and peer relationships, socioeconomic conditions, characteristics of the living environment, stressful life circumstances, and the level of social support, can play a role in shaping the risk of addiction.[49] Therefore, addictions should be assessed in the context of the interaction between individual predispositions and environmental conditions. Adverse changes in the social and physical environment can affect individuals' living conditions, stress levels, and mental health, alter social relationships and daily lifestyle habits, and thereby increase the risk of addiction. Within this framework, it is important to examine separately the potential effects of environmental changes and climate change on addictions.

1.4. The Relationship Between Climate Change and Addiction

The relationship between climate change and addiction has become an increasingly researched area of public health in recent years. This relationship is examined through a range of interrelated factors, including the deterioration of mental health, psychosocial stress, socioeconomic difficulties, the physiological effects of extreme heat, and disruptions in access to healthcare services. This section addresses the relationship within the context of the emerging scientific literature on factors such as climate-related disasters and long-term environmental changes, their effects on psychological and physical health, and the continuity of addiction services.

Studies in the literature have primarily focused on the effects of climate change on mental health and psychosocial well-being. Both sudden-onset climate-related disasters (e.g., floods and wildfires) and slow-onset changes (e.g., rising temperatures) adversely affect mental health, particularly among vulnerable groups, contributing to anxiety, depression, post-traumatic stress disorder (PTSD), suicidal tendencies, and substance use.[50] Climate

43 *UNODC, World Drug Report 2025: Contemporary Issues on Drugs.*

44 *UNODC, World Drug Report 2025: Contemporary Issues on Drugs.*

45 Wardle et al., "Lancet Public Health Commission on Gambling"; World Health Organization, "Gambling," December 2, 2024, https://www.who.int/news-room/fact-sheets/detail/gambling.

46 WHO Framework Convention on Tobacco Control, *2025 Global Progress Report on Implementation of the WHO Framework Convention on Tobacco Control* (Geneva: World Health Organization, 2025), https://fctc.who.int/resources/publications/m/item/2025-global-progress-report-on-implementation-of-the-who-fctc.

47 Jakob Manthey et al., "What Are the Economic Costs to Society Attributable to Alcohol Use? A Systematic Review and Modelling Study," *PharmacoEconomics* 39, no. 7 (2021): 809–822.

48 Seyithan Ahmet Ateş, Elif Nuroğlu, Hüseyin Hayri Nuroğlu, and Muradiye Ateş, *Bağımlılık Ekonomisi: Sigara, Alkol, Kumar ve Uyuşturucu Bağımlılığının Türkiye Ekonomisine Maliyeti* (Türkiye Yeşilay Cemiyeti, 2025), https://www.yesilay.org.tr/media/lwrptawz/bagimliligin-ekonomiye maliyeti-raporu-2025.pdf.

49 Zachary F. Gerring et al., "The Genetic Landscape of Substance Use Disorders," *Molecular Psychiatry* 29 (2024): 3694–3705; Chunqing Lin et al., "A Scoping Review of Social Determinants of Health's Impact on Substance Use Disorders over the Life Course," *Journal of Substance Use and Addiction Treatment* 166 (2024): 209484; Volkow and Blanco, "Substance Use Disorders."

50 A. M. H. Ramadan and A. G. Ataallah, "Are climate change and mental health correlated?" *General Psychiatry* 34, no. 6 (2021): e100648. https://doi.org/10.1136/gpsych-2021-100648; K. Burrows et al., "A systematic review of the effects of chronic, slow-onset climate change on mental health." *Nature Mental Health* 2, no. 2 (2024): 228-243.

change may influence the use of addictive substances by increasing the psychosocial distress experienced by individuals. Factors associated with climate change, such as damage to livelihoods, housing insecurity, weakened social support networks, and a diminished sense of security, can adversely affect individuals and create conditions that may lead to the use of addictive substances as a coping mechanism.[51] This perspective is also consistent with the literature on addiction. Prolonged stress, traumatic experiences, social isolation, and recurrent adverse life events are known to disrupt the functioning of the brain's reward and stress systems, thereby increasing the risk of initiating substance use, experiencing intense cravings, losing control over substance use, and returning to use after a period of abstinence.[52]

This link between mental health and addictions has become more evident in studies conducted following climate-related disasters. Studies have reported increases in the use of addictive substances following disasters such as hurricanes, wildfires, floods, and droughts. These increases are particularly associated with post-traumatic stress symptoms, severe anxiety, and other mental health problems.[53] A study examining the effects of wildfires projected that the prevalence of opioid misuse could increase from 5.3% to 6.0–7.2% following wildfire exposure, with an increase in anxiety symptoms potentially playing a significant role in this rise.[54] However, it is important to recognize that the effects of climate-related disasters on addictions do not manifest uniformly across all events and populations; they may vary depending on factors such as the nature of the disaster, the level of exposure, and individual and societal vulnerabilities.[55]



The risks that climate change may pose in relation to addiction are not limited to acute disasters. Long-term climatic changes, such as drought, rising temperatures, ecosystem degradation, and the gradual loss of livelihoods, may also increase the risk of addiction. Such environmental changes have been found to be associated with depressive symptoms, anxiety, and concerns about the future. These psychological difficulties are also among the established risk factors for substance addiction.[56] Substance use may emerge as a coping mechanism in response to the socioeconomic difficulties and psychological problems associated with climate change.[57]

Climate change-related disruptions to sleep patterns are also considered an important intermediate mechanism. Rising temperatures, particularly through increases in nighttime temperatures, can adversely affect sleep duration and quality. Global studies have shown that rising nighttime temperatures are associated with reduced sleep duration and sleep disturbances.[58] Sleep problems, in turn, are considered an important risk factor for addiction due to their effects on stress management, emotional regulation, and impulse control.[59]

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51 E. L. Lawrance, "Crises impact youth mental health: Climate psychology." *Nature Climate Change* 14, No. 10 (2024): 1016-1017.; F. Vergunst and H. L. Berry, "Climate change and children's mental health: a developmental perspective." *Clinical Psychological Science* 10, no. 4 (2022): 767-785.; L. A. Palinkas and M. Wong, "Global climate change and mental health." *Current Opinion in Psychology* 32 (2020): 12–16. https://doi.org/10.1016/j.copsyc.2019.06.023

52 Rajita Sinha, "Stress and Substance Use Disorders: Risk, Relapse, and Treatment Outcomes," Journal of Clinical Investigation 134, no. 16 (2024): e172883, https://doi.org/10.1172/JCI172883; George F. Koob and Jay Schulkin, "Addiction and Stress: An Allostatic View," Neuroscience G Biobehavioral Reviews 106 (2019): 245–262, https://doi.org/10.1016/j.neubiorev.2018.09.008

53 Guillaume Chevance et al., "Thinking Health-related Behaviors in a Climate Change Context: A Narrative Review," Annals of Behavioral Medicine 57, no. 3 (2023): 193–204, https://doi.org/10.1093/abm/kaac039; Tara J. Crandon et al., "The Clinical Implications of Climate Change for Mental Health," Nature Human Behaviour 6, no. 11 (2022): 1474–1481, https://doi.org/10.1038/s41562-022-01477-6; Luca Tomassini et al., "Exploring the Nexus of Climate Change and Substance Abuse: A Scoping Review," International Journal of Environmental Research and Public Health 21, no. 7 (2024): 896, https://doi.org/10.3390/ijerph21070896.

54 S. Maya, A. Mirzazadeh, and J. G. Kahn, "Effect of wildfire on the prevalence of opioid misuse through anxiety among young adults in the United States: A modeling study." *BMC Public Health* 24 (2024): 1915. https://doi.org/10.1186/s12889-024-19417-6

55 S. MacLean et al., "How does climate change impact people who use alcohol and other drugs? A scoping review of peer reviewed literature." *International Journal of Drug Policy* 134 (2024): 104649. https://doi.org/10.1016/j.drugpo.2024.104649; Maya, Mirzazadeh and Kahn, "Effect of Wildfire on the Prevalence of Opioid Misuse."

56 Burrows et al., "A Systematic Review of the Effects of Chronic, Slow-Onset Climate Change on Mental Health"; Palinkas and Wong, "Global Climate Change and Mental Health."

57 A. Y. Abdulwahab et al., "Climate variability, poverty and substance use disorders: Exploring maladaptive coping mechanisms in climate-stressed communities of Northwest Nigeria." *Journal of Public Health in Africa* 17, no. 1 (2026): 1665.

58 Z. A. Caddick, B. J. Smith, and T. Astell-Burt, "A systematic review of ambient heat and sleep in a warming climate." *Sleep Medicine Reviews* 75 (2024): 101915. https://doi.org/10.1016/j.smrv.2024.101915

59 B. P. Hasler et al., "Circadian rhythms, sleep, and substance abuse." *Sleep Medicine Reviews* 16, no. 1 (2012): 67–81. https://doi.org/10.1016/j.smrv.2011.06.001; S. Chakravorty, N. S. Chaudhary, and K. J. Brower, "Alcohol dependence and its relationship with insomnia and other sleep

Therefore, sleep disturbances associated with the long-term effects of climate change (e.g., rising temperatures) are considered an indirect factor that may increase the risk of addiction through mechanisms involving mental health and stress.

One of the psychological effects of long-term environmental changes is climate anxiety and concern about the future (eco-anxiety). Research has shown that intense anxiety about climate change, particularly among children and young people, is associated with general psychological distress, depressive symptoms, anxiety, and stress symptoms.[60] Although studies demonstrating a direct increase in addiction risk as a result of these symptoms remain limited, it has been suggested that they may lead individuals to turn to addictive substances and behaviors as a maladaptive coping mechanism.[61]

Various changes associated with climate change may also increase addiction-related risks. Among the climatic factors investigated in this field, temperature is one of the most extensively studied. Rising temperatures have been found to increase emergency department visits, hospital admissions, and overdose deaths associated with alcohol, stimulants, and opioids due to dehydration, cardiovascular strain, and sedation.[62] A meta-analysis found that extreme high temperatures were associated with an approximately 11% increase in emergency healthcare visits related to substance use disorders.[63]

The physiological effects of substances may also play an important role in increasing the health risks associated with substance use during periods of high temperatures. As stimulants can increase muscle activity and body temperature, they may exacerbate fluid loss during heatwaves and increase the risk of kidney damage and excessive cardiovascular strain.[64] On the other hand, sedation and reduced alertness, which are among the adverse effects of psychoactive substances, may make it more difficult for individuals to recognize excessively hot environments, move away from them, or take protective measures.[65]

Climate change may also affect the continuity of addiction services. Treatment systems, access to medication and supply conditions, housing availability, and social resources that support recovery may be adversely affected by climate change, potentially increasing the risk of relapse and preventable morbidity.[66] Disruptions in access to addiction treatment and the deterioration of living conditions that support recovery may negatively affect treatment outcomes.[67] Furthermore, problems such as restricted transportation options and disruptions to electricity and other essential services have been found to interfere with access to addiction treatment services.[68] It is therefore important to ensure that addiction services, like all other areas of healthcare, are prepared for climate-related disasters, that continuity of care is safeguarded, and that personnel working in the field of addiction receive training on climate-related risks.[69]

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disorders." *Alcoholism: Clinical and Experimental Research* 42, no. 6 (2018): 1111–1122. https://doi.org/10.1111/acer.13746

60 Suzanne M. Cosh et al., "The Relationship Between Climate Change and Mental Health: A Systematic Review of the Association Between Eco-Anxiety, Psychological Distress, and Symptoms of Major Affective Disorders," BMC Psychiatry 24 (2024): 833, https://doi.org/10.1186/s12888-024-06274-1; Susan Clayton, "Climate Anxiety: Psychological Responses to Climate Change," Journal of Anxiety Disorders 74 (2020): 102263, https://doi.org/10.1016/j.janxdis.2020.102263.; Léger-Goodes et al., "Eco-anxiety in children: A scoping review of the mental health impacts of the awareness of climate change." *Frontiers in psychology* 13 (2022): 872544.

61 S. Tayyab and S. Jabeen, "Climate change induced anxiety, perceived stress and coping strategies in young adults: Evidence from Pakistan." *Journal of Professional h Applied Psychology* 6, no. 4 (2025): 536–544.

62 H. H. Chang et al., "Associations between short-term ambient temperature exposure and emergency department visits for amphetamine, cocaine, and opioid use in California from 2005 to 2019." *Environment International* 181 (2023): 108233. https://doi.org/10.1016/j.envint.2023.108233; R. M. Parks et al., "The association between temperature and alcohol- and substance-related disorder hospital visits in New York State." *Communications Medicine* 3 (2023): Article 118. https://doi.org/10.1038/s43856-023-00346-1

63 H. Jhang et al., "Extreme ambient temperature and emergency healthcare service utilization due to substance use disorders: A systematic review and meta-analysis." *Scientific Reports* 15, no. 1 (2025): 13582.

64 MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs?"; Chang et al., "Associations Between Short-Term Ambient Temperature Exposure and Emergency Department Visits."

65 Chang et al., "Associations Between Short-Term Ambient Temperature Exposure and Emergency Department Visits."

66 Jenna L. Butner et al., "The Health Impacts of Climate Change on People Who Use Alcohol and Other Drugs: Position Statement of AMERSA, Inc. (Association for Multidisciplinary Education and Research in Substance Use and Addiction)," Substance Use G Addiction Journal 47, no. 4 (2026): 953–958, https://doi.org/10.1177/29767342261461050; MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs?"

67 Butner et al., "The Health Impacts of Climate Change on People Who Use Alcohol and Other Drugs."; E. A. Bowen, "To change what we cannot accept: acknowledging and addressing the impact of climate change on addiction recovery capital." *Addiction Research & Theory* 32, no. 6 (2024): 466-476.

68 Julia A. Dunn et al., "Disruption of Opioid Treatment Program Services Due to an Extreme Weather Event: An Example of Climate Change Effects on the Health of Persons Who Use Drugs," Journal of Addiction Medicine 19, no. 3 (2025): 245–247, https://doi.org/10.1097/ADM.0000000000001403; Tarik Benmarhnia, "Commentary on Dennett et al.: When Heat and the Opioid Epidemic Collide—Implications for Climate-Resilient Public Health Strategies," Addiction 121, no. 2 (2026): 286–287, https://doi.org/10.1111/add.70302; Butner et al., "The Health Impacts of Climate Change on People Who Use Alcohol and Other Drugs."

69 Butner et al., "The Health Impacts of Climate Change on People Who Use Alcohol and Other Drugs."

Climate change can also affect the social and daily living conditions necessary to address addiction. Recovery depends not only on the continuation of treatment but also on resources that support recovery, such as individuals' social support networks, safe living conditions, personal resources, and opportunities for participation in community life. Climate-related disasters and displacement can disrupt individuals' ability to maintain connections with support groups, preserve daily routines, and sustain relationships with their social environment.[70] This is consistent with findings on the social determinants of health, which have shown that risk factors such as housing insecurity, unemployment, stigma, and inadequate social support can adversely affect continuity of addiction treatment and the recovery process.[71] By exacerbating these social and economic risk factors, climate change may also increase the risk of relapse.[72]

As the effects of these risks may vary across different segments of society, children and young people are among the groups requiring particular attention. Young people will be exposed to the effects of climate change for a longer period over the course of their lives. Consequently, heightened concerns about the future and a more pronounced sense of environmental loss in this group may also increase the risk of addiction.[73] Studies have shown that symptoms of post-traumatic stress disorder (PTSD), depression, and anxiety may persist for years among young people exposed to climate-related disasters.[74] Therefore, strengthening psychological resilience, stress-coping skills, help-seeking behaviors, and social support systems in addiction prevention initiatives targeting young people is also important for climate change adaptation.

The literature discussed so far consists primarily of studies focusing on substance addictions. However, although research on the relationship between climate change and behavioral addictions remains more limited than that on substance addictions, the number of studies in this area is growing. Studies have indicated that temperature shocks may be associated with gambling behavior and the risk of gambling-related harm,[75] and that traumatic stress following climate-related disasters may predict subsequent symptoms of problematic online gaming among adolescents.[76] *Climate-related doomscrolling*, defined as the repetitive consumption of negative news about climate change, is also emerging as a new area of research and has been found to be associated with anxiety and depressive symptoms.[77]

When considered together, the existing findings indicate that the relationship between climate change and addiction involves multiple mechanisms. Climate-related physical and psychosocial stressors, deterioration in mental health, weakening economic and social conditions, changes in daily routines, and disruptions in access to healthcare services constitute cumulative risk factors.[78] These conditions may increase the risk of addiction in some individuals, while among those already experiencing addiction, they may make substance use more hazardous, hinder access to treatment services, and contribute to increases in overdose deaths and other health problems.[79] Therefore, rather than indicating a linear relationship between climate change and addiction, the existing literature suggests that climate-related events and long-term environmental changes may create conditions that exacerbate existing vulnerabilities to addiction.[80]

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70 Bowen, "To change what we cannot accept: acknowledging and addressing the impact of climate change on addiction recovery capital"

71 A. Li, M. Toll, and R. Bentley, "Mapping social vulnerability indicators to understand the health impacts of climate change: a scoping review." *The Lancet Planetary Health* 7, no. 11 (2023): e925-e937.

72 Parks et al., "The Association Between Temperature and Alcohol- and Substance-Related Disorder Hospital Visits in New York State."; Crandon et al., "The Clinical Implications of Climate Change for Mental Health."; E. L. F. Schipper et al., "The debate: Is global development adapting to climate change?" *World Development Perspectives* 18 (2020): 100205. https://doi.org/10.1016/j.wdp.2020.100205

73 F. Vergunst et al., "Climate change and substance-use behaviors: A risk-pathways framework." *Perspectives on Psychological Science* 18, no. 4 (2023): 936–954. https://doi.org/10.1177/17456916221132739

74 J. L. Barkin et al., "Effects of extreme weather events on child mood and behavior." *Developmental Medicine h Child Neurology* 63, no. 7 (2021): 785–790.; S. E. Burke, A. V. Sanson, and J. Van Hoorn, "The psychological effects of climate change on children." *Current Psychiatry Reports* 20, no. 5 (2018): 35.

75 Trong-Anh Trinh et al., "Temperature Shocks and Gambling," Energy Economics 115 (2022): 106406, https://doi.org/10.1016/j.eneco.2022.106406.

76 G. F. Yuan et al., "Longitudinal associations among posttraumatic stress symptoms, intolerance of uncertainty and internet gaming disorder symptoms among disaster-exposed adolescents." *Addictive Behaviors* 179 (2026): 108686. https://doi.org/10.1016/j.addbeh.2026.108686

77 A. Dominguez-Rodriguez et al., "Climate change news and doomscrolling: An examination of influencing factors and psychological effects." *Acta Psychologica* 255 (2025): 104925.

78 Vergunst et al., "Climate Change and Substance-Use Behaviors"; MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs?"

79 MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs?"; Butner et al., "The Health Impacts of Climate Change on People Who Use Alcohol and Other Drugs."

80 Vergunst et al., "Climate Change and Substance-Use Behaviors"; MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs?"

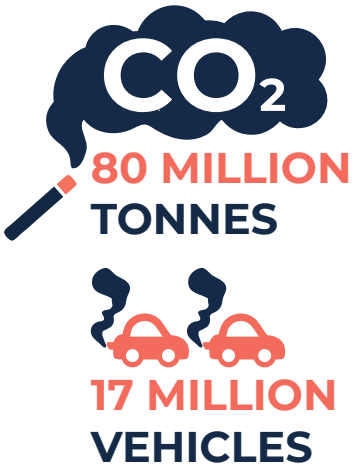


CHAPTER 2:
THE ENVIRONMENTAL FOOTPRINT OF ADDICTION INDUSTRIES

The impacts of addiction industries are not limited to health and social consequences; they also impose a considerable environmental burden. The production processes of tobacco, alcohol, and illicit drugs generate multidimensional environmental costs, including water and energy consumption, deforestation, greenhouse gas emissions, chemical pollution, and waste generation. These costs threaten planetary health by contributing to ecosystem degradation and accelerating climate change, while also exerting direct and indirect effects on public health. Accordingly, making the environmental footprint of addiction industries visible, examining it within the context of sustainable development and environmental policies, and analytically addressing the intersections between health and the environment have become scientific imperatives. Furthermore, with the advancement of digitalization, the gambling and gaming industries are also generating a new form of "digital burden" through energy consumption, electronic waste generation, and social vulnerabilities. This further highlights the multidimensional nature of the environmental and social costs associated with addiction industries.

2.1. Environmental Impacts of the Tobacco Industry

Among addiction industries, the tobacco industry is one of the sectors whose impacts on the planet are most frequently highlighted. According to WHO data, tobacco production and consumption generate approximately 80 million tonnes of carbon dioxide (CO_2) emissions annually, equivalent to the yearly emissions of approximately 17 million gasoline-powered vehicles. Accordingly, the industry is considered not only a public health concern due to the diseases and premature deaths it causes, but also a major environmental and sustainable development concern because of its impacts on climate change, natural resource depletion, and biodiversity loss.[1] Throughout the tobacco life cycle, from cultivation to waste generation, the tobacco industry exerts environmental pressures at every stage, including agricultural production, curing and processing, manufacturing and distribution, and post-consumption waste, through activities such as tree felling and excessive water consumption. In addition to generating substantial environmental costs through deforestation, drought, and greenhouse gas emissions, these pressures also contribute to plastic and toxic chemical pollution through cigarette butts, which are among the most widespread forms of environmental litter worldwide.[2]



The report published in 2025 by the Secretariat of the WHO Framework Convention on Tobacco Control (WHO FCTC) assesses the environmental damage occurring throughout the tobacco life cycle, from cultivation and manufacturing to distribution, consumption, and post-consumption waste, and outlines regulatory policy options to prevent such damage.[3] Proposed measures include banning cigarette filters, restricting tobacco products containing single-use plastics, imposing restrictions on electronic cigarettes, implementing extended producer responsibility, improving waste management, and promoting environmental awareness.[4] Accordingly, within this broader framework, environmental damage can be examined under two main categories: environmental damage caused by tobacco production, and environmental damage arising from the supply chain, marketing, and waste associated with tobacco products.

1 World Health Organization, Tobacco: Poisoning Our Planet (Geneva: World Health Organization, 2022), 1, https://www.who.int/publications/i/item/9789240051287 (Accessed: 14 August 2026).

2 World Health Organization Framework Convention on Tobacco Control (WHO FCTC), Regulatory Options to Prevent Environmental Harm and Pollution Across the Tobacco Product Life Cycle, 29 September 2025, 31-39, https://iris.who.int/server/api/core/bitstreams/9139e9ae-0006-4a30-8ec0-6e01617d35f7/content (Accessed: 14 August 2026).

3 In the report, these policy options are categorized into three regulatory approaches: upstream measures, which aim to prevent environmental damage at the production and product design stages; midstream measures, which focus on reducing waste generation during the use and sale of tobacco products; and downstream measures, which address the management, disposal, and cleanup of waste generated after consumption. See ibid., pp. 46–55.

4 Ibid., pp. 56–60. The report was prepared pursuant to Decision FCTC/COP10(14), Implementation of Article 18 of the WHO FCTC, adopted at the Tenth Session of the Conference of the Parties to the WHO Framework Convention on Tobacco Control (WHO FCTC) in February 2024, and within the scope of the tasks assigned to the Convention Secretariat under this decision. Under Article 18 of the WHO FCTC, Parties are required to give due consideration to the protection of the environment and the health of persons in relation to tobacco cultivation and manufacturing within their respective territories. For the decision of the Conference of the Parties to the WHO FCTC, see Conference of the Parties to the WHO Framework Convention on Tobacco Control (WHO FCTC), "Implementation of Article 18 of the WHO FCTC," Decision FCTC/COP10(14), 10 February 2024, https://iris.who.int/server/api/core/bitstreams/a95dd820-e55d-45b6-b0be-f6aaa1b76d12/content (Accessed: 14 August 2026).

2.1.1. Environmental Damage Caused by Tobacco Production

The adverse effects of tobacco on the environment and human health begin long before the product is consumed. Tobacco is cultivated in 124 countries worldwide, occupying approximately 3.2 million hectares of productive agricultural land.[5] Tobacco farming contributes to deforestation, soil degradation, and the depletion of water resources. For example, approximately 22 billion tonnes of water are used globally for tobacco production. Furthermore, tree felling to clear land for tobacco cultivation and obtain wood for curing accounts for approximately 5% of global deforestation.[6] In the case of cigarettes specifically, approximately 3.7 litres of water are used throughout the life cycle of a single cigarette, while the production of approximately 300 cigarettes requires the felling of one tree.[7]

Tobacco production also consumes substantially more water than many other crops. Tobacco cultivation may require up to eight times more water than the production of crops such as tomatoes or potatoes. In addition, because tobacco farming requires the intensive use of pesticides and fertilizers, these chemicals degrade soil structure and contaminate water resources. Another concern is that tobacco fields are more susceptible to soil erosion and desertification. This indicates that, compared with other agricultural activities, tobacco cultivation can have more destructive effects on ecosystems.[8] The production and use of agricultural machinery, as well as plastic materials used for ground cover and plastic sheeting employed to prevent erosion, should also be considered additional environmental costs. Although the lack of transparency within the tobacco industry makes it difficult to fully determine the environmental impacts of the production stage, emissions associated with energy consumption during manufacturing and the resulting liquid and solid waste inevitably have significant adverse effects on the environment. These wastes primarily consist of tobacco sludge, solvents, oils, paper, plastics, and packaging materials.[9]

2.1.2. Environmental Damage Arising from the Supply Chain, Marketing, and Waste

The post-production supply chain, marketing, and waste generated by the consumption of tobacco products create additional ecological costs through transportation, packaging, and use, extending beyond the environmental impacts of the production stage alone. Tobacco products also contribute to carbon dioxide emissions through transportation, while the use of plastics in filters and packaging materials causes further environmental damage.[10] Harvested tobacco leaves are transported to factories, where they are processed into cigarettes and other tobacco products. This process involves the use of numerous additional materials, including not only tobacco but also plastic filters, flavourings, additives, cigarette paper, cardboard boxes, cellophane, and other plastic packaging materials.

Tobacco product waste (TPW) encompasses cigarette butts, cigarette packaging, electronic cigarette components, and other tobacco-related litter. TPW, particularly cigarette butts, is among the most commonly encountered types of litter. During a volunteer-led coastal cleanup initiative conducted in the United States in 2022, more than 1.1 million cigarette butts were collected. These butts account for approximately 30% of the total litter collected in many cleanup activities. In addition to volunteer cleanup initiatives, inspections targeting TPW in various cities have found that cigarette butts account for 10% to 20% of all small-sized litter.[11]

5 World Health Organization, World No Tobacco Day 2023: Grow Food, Not Tobacco (Geneva: World Health Organization, 2023), 5, https://iris.who.int/items/a7c61f71-2cee-4f33-b76b-2f37cbef32f5 (Accessed: 17 August 2026)

6 The burning of wood or coal is common in systems used to cure tobacco leaves. Consequently, tobacco production accelerates deforestation both through the clearing of land for cultivation and through the demand for wood required for the curing process. See WHO FCTC, Regulatory Options to Prevent Environmental Harm and Pollution Across the Tobacco Product Life Cycle, 23

7 WHO, Tobacco: Poisoning Our Planet, 1-3.

8 loc. cit.

9 WHO FCTC, Regulatory Options to Prevent Environmental Harm and Pollution Across the Tobacco Product Life Cycle, 23-24.

10 WHO, Tobacco: Poisoning Our Planet, 4.

11 Maddie Leestma, Thomas E. Novotny, Ronald Shadbegian, John Schneider, Juleen Lam, Nicolas Lopez-Galve, and Rebecca J. Williams, "Tobacco Product Waste Cleanups and Costs," Discover Environment 3, no. 43 (2025), https://doi.org/10.1007/s44274-025-00234-6 (Accessed: 17 August 2026)

Approximately 6 trillion cigarettes are produced annually and marketed in around 300 billion packs, using packaging materials such as paper, ink, cellophane, foil, and adhesives.[12] Cigarette butts discarded into the environment release harmful substances into soil and water, posing risks to ecosystems and human health. Moreover, their cellulose acetate filters persist in the environment for extended periods, contributing to long-lasting pollution.[13] Single-use plastics and metals are also used in the packaging of smokeless tobacco products, such as chewing tobacco and nicotine pouches. This generates solid waste, increases the burden on landfills, and can lead to the leaching of toxic chemicals from these sites into the environment.[14] Electronic cigarette waste also contains metals, plastics, electronic circuits, and residual chemical liquids, making it a significant source of waste that contributes to environmental pollution.[15]

Unlike other addictive substances, the direct environmental impacts of tobacco also occur during its use. Tobacco smoke contains greenhouse gases such as CO_2, methane, and nitrogen oxides, and generates higher levels of particulate matter pollution than diesel exhaust. In addition, cigarette butts remain a significant cause of accidental fires and wildfires.[16]

According to data from the Ministry of Agriculture and Forestry, approximately 150.4 billion cigarettes were consumed in Türkiye in 2024. This figure has been reported as the highest recorded level of cigarette consumption in the history of the Republic.[17] A study conducted between February and August 2024 across eight different urban areas and 26 locations in Türkiye, including shopping mall entrances, bus stops, and metro entrances, identified a total of 1,684 cigarette butts. Cigarette butt density was found to be particularly high at bus stops, hospital entrances and exits, and in parks. According to the results of the *Cigarette Butt Pollution Index*, only two of the 26 locations were classified as having low pollution levels, while 13 were classified as having severe pollution, four as having very high pollution, and seven as having significant pollution. The findings indicate that cigarette butts are a widespread form of litter in urban environments. Owing to their cellulose acetate fibres, nicotine, heavy metals, and other toxic substances, they constitute a significant environmental problem that extends beyond visual pollution, as they can persist in soil and aquatic environments for prolonged periods and adversely affect ecosystems. The study also emphasizes that cigarette butts can be transported by rainfall and surface runoff, causing chemical pollution. Accordingly, it highlights the need to develop awareness-raising initiatives, infrastructure, and enforcement measures to monitor and prevent cigarette butt pollution.[18]

2.1.3. Environmental Health Impacts of Tobacco Products

The environmental impacts of the tobacco industry should not be considered solely in terms of natural resource consumption or environmental pollution. The life cycle of tobacco, from production to post-consumption waste, triggers a range of interrelated environmental changes, including climate change, ecosystem degradation, biodiversity loss, pressure on water and soil resources, and chemical pollution. Therefore, the environmental footprint of the tobacco industry should be assessed within a framework that recognizes the inseparable relationship between planetary health and human health. In fact, the WHO FCTC addresses the environmental impacts of tobacco throughout its entire life cycle, from “cradle to grave.”[19]

The public health significance of the environmental impacts of the tobacco industry stems from the fact that environmental degradation also has consequences for human health. Deforestation, the depletion and contamination of water resources, pesticide and fertilizer use, air pollution, plastic and microplastic pollution, toxic waste, and fire hazards can affect not only ecosystems but also workers, farmers, communities, and consumers who come into contact with these environmental factors. Therefore, the environmental footprint of tobacco and its health burden should not be regarded as two independent outcomes, but rather as

12 WHO, Tobacco: Poisoning Our Planet, 4.

13 Leestma et al., “Tobacco Product Waste Cleanups and Costs,”.

14 WHO, Tobacco: Poisoning Our Planet, 4.

15 Leestma et al., “Tobacco Product Waste Cleanups and Costs,”.; most of these products are single-use items made from non-biodegradable and non-recyclable materials and can cause environmental harm. See WHO, Tobacco: Poisoning Our Planet, 5.

16 For example, in 2010, a fire caused by a cigarette butt in India damaged 60 hectares of forest. See WHO, Tobacco: Poisoning Our Planet, 5.

17 “2024’te Tütün Tüketimi Rekor Kırdı: Vergi Gelirleri ise Hedefleri Aştı,” Ekonomim, 26 Mayıs 2025, https://www.ekonomim.com/ekonomi/2024te tutun-tuketimi-rekor-kirdi-vergi-gelirleri-ise-hedefleri-asti-haberi-820540 (Erişim Tarihi: 6 Ekim 2026).

18 Seher Küçükfarsak, “Sigara İzmaritlerinin Oluşturduğu Kirliliğin Sigara İzmariti Kirlilik İndeksi ile Değerlendirilmesi: Bir Kentsel Çevre Örneği” (Yüksek Lisans Tezi, Atatürk Üniversitesi Fen Bilimleri Enstitüsü, Çevre Mühendisliği Anabilim Dalı, 2026).

19 WHO, Tobacco: Poisoning Our Planet, 5.



interconnected consequences that reinforce one another throughout the same life cycle. Indeed, second-hand tobacco smoke (passive smoking) is considered by the World Health Organization to be a component of indoor air pollution. Containing fine particulate matter, carbon monoxide, and other pollutants, as well as approximately 7,000 chemicals, it reduces indoor air quality and constitutes a significant source of environmental exposure. The treatment of diseases resulting from both passive smoking and the direct consumption of tobacco products also represents a substantial environmental cost for healthcare systems.[20]

The relationship between the tobacco industry and climate change should not be assessed solely in terms of the sector's greenhouse gas emissions. Climate change also affects the environments in which tobacco is cultivated and the producers themselves through rising temperatures, drought, water scarcity, changing precipitation patterns, wildfires, and changes in agricultural production conditions. Conversely, greenhouse gas emissions generated during tobacco production and processing, deforestation, and intensive resource consumption are among the factors contributing to climate change. This gives rise to a bidirectional interaction between climate change and the tobacco industry.[21]

The environmental burdens of tobacco are not distributed equally across all segments of society. Tobacco growers and agricultural workers are directly exposed to pesticides, fertilizers, dust, heat, and other occupational hazards, while communities in tobacco-producing areas may be affected by the loss of water and soil resources and ecosystem degradation. In urban areas where post-consumption waste accumulates, children, outdoor workers, sanitation workers, and other groups exposed to higher levels of environmental pollution may face different risks.[22] Therefore, environmental justice and health inequalities must also be taken into account when assessing the environmental costs of the tobacco industry. These costs become more apparent through the unequal distribution of environmental burdens across different segments of society and the inequitable consequences of socioeconomic disparities for health risks and access to treatment.

The environmental impacts of the tobacco industry also generate hidden health costs. Environmental degradation, air and water pollution, waste, fires, and risks associated with climate change can increase the demand for healthcare services and place an additional burden on health systems. Therefore, the true cost of the tobacco industry should be assessed not only in terms of the economic value generated during production and consumption, but also by taking into account environmental damage, health losses, healthcare costs, and the burdens transferred to future generations.

The environmental impacts of the tobacco industry should also be assessed from a One Health perspective. Considering the interrelationships among soil, water, vegetation, biodiversity, and human health, the environmental impacts of tobacco production should be viewed not merely as an "environmental problem," but as a shared concern involving both ecosystem health and human health.

The growing prevalence of electronic cigarettes and other electronic nicotine products has also broadened the scope of tobacco product waste. In addition to plastic and metal components, these products contain batteries, electronic circuits, and nicotine-containing liquids. Unlike conventional cigarette butts, they therefore constitute an emerging environmental health concern at the intersection of electronic waste, chemical waste, and plastic pollution.

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20 World Health Organization Regional Office for Europe (WHO Europe), "Second-Hand Smoke: The Invisible Killer That Continues to Cause Death and Disease," 4 May 2023, https://www.who.int/europe/news/item/04-05-2023-secondhand-smoke-the-invisible-killer-that-continues-to-cause-death-and-disease (Accessed: 6 October 2026). Therefore, the indirect environmental costs associated with all healthcare services related to tobacco use and exposure should also be taken into account. For further information on modelling the carbon footprint of healthcare systems in general, see Matthew J. Eckelman, Kathryn Lagasse, Stefanie N. B. Sullivan, and Jonathan D. Patz, "Modeling National Health Care System Carbon Footprints: Opportunities, Challenges and Recommendations," The Lancet Planetary Health 6, no. 9 (2022): e760–e766, https://pmc.ncbi.nlm.nih.gov/articles/PMC9541808/ (Accessed: 6 October 2026).

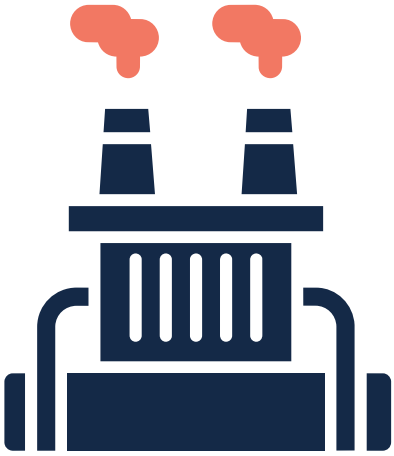
21 WHO, Tobacco: Poisoning Our Planet, Cigarette Smoking: An Assessment of Tobacco's Global Environmental Footprint Across Its Entire Supply Chain | WHO FCTC .

22 *U.S. Department of Health and Human Services, Eliminating Tobacco-Related Disease and Death: Addressing Disparities. A Report of the Surgeon General (Washington, DC: U.S. Department of Health and Human Services, Office of the Surgeon General, 2024).*

2.2. Environmental Impacts of the Alcohol Industry

The environmental impacts of the alcohol industry have received less attention than the health and social consequences of alcoholic beverages. Nevertheless, the production of beer, wine, and distilled spirits[23] relies on extensive production and supply chains that require the use of natural resources, from the cultivation of agricultural raw materials to the delivery of finished products to consumers. In this respect, the alcohol industry is a sector that warrants assessment not only from a public health perspective but also in terms of the environmental impacts of its production and consumption processes.

These environmental impacts vary depending on the type of product and the region in which it is produced, and arise at different stages of the production chain. The process begins with the cultivation of barley and hops for beer, grapes for wine, and various grains, sugarcane, and other agricultural products for distilled spirits. It then continues through raw material processing, fermentation or distillation, cooling, packaging, storage, and distribution. Glass, metal, and other packaging waste generated after consumption constitutes the final stage of this chain. Accordingly, the environmental footprint of the alcohol industry can be examined through three interrelated areas: agricultural production, carbon and water use, and packaging and waste.



Although research on the environmental impacts of alcohol remains more limited than the literature on the environmental impacts of the tobacco industry, existing findings indicate that the sector imposes a considerable environmental burden in terms of land, energy, and water use, greenhouse gas emissions, wastewater, and packaging waste. An assessment of the current state of knowledge on the environmental impacts of alcohol production highlights the resource- and energy-intensive nature of alcoholic beverage production. It also reveals that the environmental dimensions of alcohol policies have not been adequately addressed in the public health literature.

2.2.1. Agricultural Production

The environmental footprint of alcoholic beverages begins at the agricultural raw material production stage, before the products reach manufacturing facilities. Beer production relies primarily on barley, along with other grains and hops; wine production uses grapes; and whisky, vodka, and other distilled spirits are produced using agricultural products such as wheat, barley, corn, potatoes, and sugarcane. Consequently, alcohol production entails environmental impacts associated with the use of agricultural land, water, fertilizers, pesticides, agricultural machinery, and energy. Indeed, approximately 63% of food-system-related emissions originate not from manufacturing facilities, but from agricultural production, land-use changes, and other related activities.[24]

Life cycle assessments (LCAs) of beer production indicate that barley cultivation is one of the major sources of environmental impact. A systematic review examining the life cycle of beer production identified agricultural raw material production, energy use, and packaging as the principal areas of environmental impact.[25] Nitrogen fertilisers used in barley cultivation contribute not only to greenhouse gas emissions but also to environmental impacts such as eutrophication[26] and acidification, while the use of agricultural machinery and the conversion of barley into malt further increase energy consumption.

In wine production, viticulture is one of the main components of the environmental footprint. Grape cultivation exerts environmental pressure through land use, fertiliser and pesticide applications, agricultural machinery, and

23 Distilled spirits are alcoholic beverages produced by increasing the alcohol content of a fermented liquid through distillation. Examples include rakı, vodka, whisky, rum, gin, tequila, and brandy. Beer and wine, by contrast, are produced primarily through fermentation and therefore do not fall into this category.

24 Gitnux, "Sustainability in the Alcohol Industry Statistics 2026," https://gitnux.org/sustainability-in-the-alcohol-industry-statistics/ (Accessed: 6 October 2026).

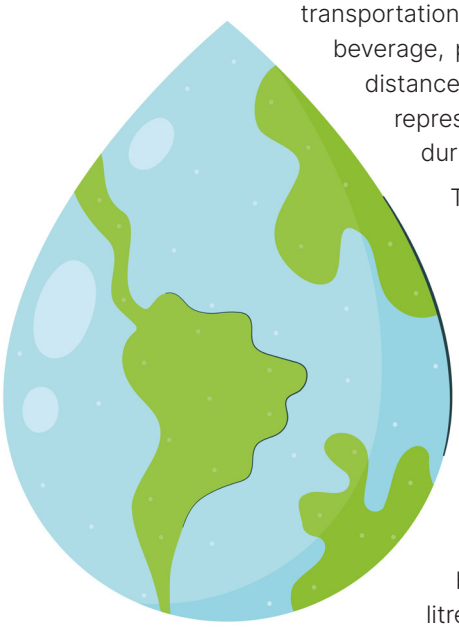
25 Fabrizio D'Ascenzo et al., "Application of Life Cycle Assessment in Beer Production: Systematic Review," *Beverages* 10, no. 3 (2024): 86, https://doi.org/10.3390/beverages10030086.

26 Eutrophication is the process by which excessive inputs of nutrients, such as nitrogen and phosphorus, into aquatic environments, including lakes, rivers, and seas, lead to the excessive growth of algae and aquatic plants.

irrigation in some production regions. Studies examining the life cycle of wine have identified viticulture, along with bottling and packaging, as among the stages that make substantial contributions to the product's carbon footprint.[27]

2.2.2. Carbon and Water Footprint

The carbon footprint of alcoholic beverages arises not only from agricultural production but also from malting, fermentation, distillation, cooling, bottling, the manufacture of packaging materials, and product transportation. The relative significance of these stages varies depending on the type of beverage, production methods, energy sources used, packaging format, and distribution distances. In particular, the production and transportation of single-use glass bottles can represent a significant source of carbon emissions, as glass requires high temperatures during manufacturing and is heavier than other types of packaging.



The pressure exerted by alcohol production on water resources can be illustrated particularly well by beer production. An analysis of five years of production data from a brewery in Addis Ababa, Ethiopia, highlights that the brewing industry may use 4–6 litres of process water to produce one litre of beer. The study demonstrates that water consumption is not limited to the brewing process itself; packaging, auxiliary operations, and general facility services also require substantial amounts of water. These findings indicate that alcoholic beverage production entails water consumption far exceeding the volume of water contained in the final product.[28] The Ethiopian case illustrates that water use can reach considerably higher levels depending on production technology and facility conditions. Another study examining wastewater generated by the brewing industry in Ethiopia reports that breweries in the country may use 9–22 litres of water to produce one litre of beer. The same study highlights that a substantial proportion of the water used in production subsequently becomes wastewater with high concentrations of organic matter and nutrients.[29]

A study conducted in Sweden based on alcohol consumption data from approximately 50,000 individuals found that the carbon footprint associated with alcoholic beverage consumption increases substantially as individual consumption levels rise. The study estimated the annual carbon footprint attributable to alcohol consumption at an average of 52 kg of CO_2-equivalent per person, while this figure reached as high as 202 kg of CO_2-equivalent among the 10% of participants with the highest alcohol consumption. Alcohol consumption accounted for an average of 3% of participants' total diet-related greenhouse gas emissions, with this proportion rising to 6–11% among high-consumption groups.[30] These findings demonstrate that alcohol consumption has consequences beyond health and social outcomes; as consumption increases, its associated carbon footprint also grows due to the production and supply chain processes required to meet demand.

In addition to water consumption, wastewater generation is another significant environmental impact of the alcohol industry. Breweries generate wastewater rich in organic matter through bottle and equipment cleaning, tank washing, production line cleaning, and other processes. When discharged into the environment without adequate treatment, this wastewater, which has a high organic load, can reduce dissolved oxygen levels in water and consequently damage aquatic ecosystems.[31]

27 Luís Pinto da Silva and Joaquim C. G. Esteves da Silva, "Evaluation of the Carbon Footprint of the Life Cycle of Wine Production: A Review," *Cleaner and Circular Bioeconomy* 2 (2022): 100021, https://doi.org/10.1016/j.clcb.2022.100021.

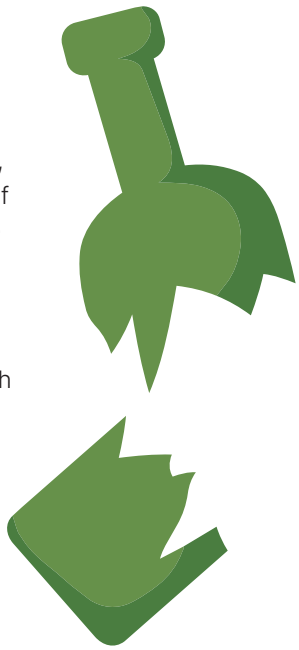
28 Kumela Diro et al., "Assessment of the Water Footprint of the Brewery Industry: The Case of Heineken, Addis Ababa, Ethiopia," *Results in Engineering* 24 (2024): 102928, https://doi.org/10.1016/j.rineng.2024.102928.

29 Abebe Worku, Nega Tefera, Helmut Kloos, and Solomon Benor, "Bioremediation of Brewery Wastewater Using Hydroponics Planted with Vetiver Grass in Addis Ababa, Ethiopia," *Bioresources and Bioprocessing* 5 (2018): 39, https://doi.org/10.1186/s40643-018-0225-5.

30 Elinor Hallström, Niclas Håkansson, Agneta Åkesson, Alicja Wolk, and Ulf Sonesson, "Climate Impact of Alcohol Consumption in Sweden," *Journal of Cleaner Production* 201 (2018): 287–294, https://doi.org/10.1016/j.jclepro.2018.07.295.

31 Luc Fillaudeau, Pascal Blanpain-Avet, and Georges Daufin, "Water, Wastewater and Waste Management in Brewing Industries," *Journal of Cleaner Production* 14, no. 5 (2006): 463–471, https://doi.org/10.1016/j.jclepro.2005.01.002.

2.2.3. Packaging and Waste



Beer, wine, and distilled spirits are predominantly marketed in glass bottles, aluminium or steel cans, and associated secondary packaging materials, including caps, labels, cardboard, and plastic. The production and transportation of packaging, such as bottles, cans, and kegs, also account for a significant share of the environmental footprint of alcoholic beverages. Packaging production requires raw materials and energy, while substantial amounts of solid waste are generated after consumption. Single-use glass bottles, in particular, can impose an environmental burden because glass manufacturing is energy-intensive and the weight of the bottles can increase transport-related emissions.

Although glass is theoretically highly recyclable, the production of new glass requires high temperatures. Furthermore, the weight of glass packaging can increase fuel consumption during transportation and, consequently, greenhouse gas emissions. Therefore, the fact that glass is "recyclable" does not automatically mean that it has the lowest environmental impact over its entire life cycle.

A recent life cycle assessment comparing beer packaging formats demonstrates that the type of packaging can substantially influence the overall environmental performance of the product. The study, which compared different beer packaging formats, found that agricultural production, packaging, and the use phase account for significant portions of the product's environmental impacts.[32]

Bottling is also a significant source of emissions in the wine industry. Studies examining the carbon footprint of wine indicate that, alongside viticulture, glass bottle production is one of the main stages contributing to environmental impacts throughout the product's life cycle.[33] Considering the energy requirements of glass manufacturing and the effects of bottle weight on transportation, it becomes clear that the environmental burden of alcoholic beverages arises not only from beverage production itself but also from the packaging required to bring these products to market.

The waste burden generated by alcohol production is not limited to packaging. Beer production generates spent grain, surplus yeast, and hop residues; wine production produces grape skins, seeds, stems, and pomace; and the production of distilled spirits generates production residues with high organic content. This demonstrates that alcoholic beverage production generates substantial quantities of organic waste that must be managed in addition to the final product itself. Limiting the environmental impacts of this waste requires additional waste management processes, including collection, transportation, processing, or disposal. Accordingly, assessments of the environmental footprint of the alcohol industry should take into account not only product and packaging waste but also the organic waste generated during production.

2.2.4. Environmental Burden from a Public Health Perspective

The environmental impacts of alcohol arise not only during production but also generate significant environmental and public health consequences at the consumption stage. In particular, in tourist destinations, entertainment districts, festival venues, and urban areas with concentrated night-time economies, alcohol consumption can lead to an increase in glass, plastic, and metal packaging waste, higher energy and water consumption, increased transport-related emissions, and additional burdens on local cleaning services. This makes it necessary to assess the environmental impacts of alcohol not only in areas where production facilities are located, but throughout the entire alcohol supply chain, from production to consumption.[34]

Environmental burden is not limited to resource consumption or greenhouse gas emissions. The diseases, injuries, traffic accidents, mental health problems, productivity losses, and healthcare costs associated with alcohol

32 Luca Marrucci, Tiberio Daddi, and Fabio Iraldo, "Identifying the Most Sustainable Beer Packaging through a Life Cycle Assessment," *Science of the Total Environment* 948 (2024): 174941, https://doi.org/10.1016/j.scitotenv.2024.174941.

33 Luís Pinto da Silva and Joaquim C. G. Esteves da Silva, "Evaluation of the Carbon Footprint of the Life Cycle of Wine Production: A Review," *Cleaner and Circular Bioeconomy* 2 (2022): 100021, accessed: 24 August 2026, https://doi.org/10.1016/j.clcb.2022.100021

34 Robin Room, "Alcohol's Contribution to Climate Change and Other Environmental Degradation: A Call for Research," Health Promotion International 39, no. 1 (2024): daae004, https://doi.org/10.1093/heapro/daae004.

consumption also constitute the public health dimension of this burden.[35] The environmental and health impacts of alcohol are interconnected and mutually reinforcing: while climate change, water stress, and environmental degradation adversely affect public health, the environmental costs arising from alcohol production and consumption can further exacerbate these risks. Therefore, it is important to consider environmental, social, and health impacts together when assessing the overall burden associated with alcohol.[36]

On the other hand, the environmental footprint of the alcohol industry cannot be assessed solely by calculating how much water, energy, or land it uses. The central public health question is which segments of society bear the costs of this resource use and environmental burden, how these impacts change with climate change, and who ultimately bears the resulting health burden. The environmental costs of alcohol are not distributed equally across society. While alcohol production and supply chains rely heavily on water, energy, and agricultural inputs, the resulting environmental pressures often fall disproportionately on rural communities dependent on water resources, agricultural workers, low-income groups, and populations that are more vulnerable to climate change. Accordingly, the environmental footprint of alcohol can be assessed not only through resource-use indicators but also from the perspective of which communities bear its environmental costs and health burdens.[37]

2.3. Psychoactive Substance Production and Environmental Degradation

Although psychoactive substances are generally addressed in terms of public health, security, and crime, their environmental impacts have also attracted increasing attention in recent years. Processes ranging from agricultural activities undertaken for the production of drugs/stimulants and the chemicals used in synthetic drug laboratories to land-use changes caused by trafficking networks and waste generated after consumption point to numerous forms of environmental damage.[38] Therefore, the issue of psychoactive substances should be evaluated not only from the perspectives of health and security but also in terms of environmental harm, within the framework of ecosystem protection and planetary health.

The multidimensional environmental impacts of psychoactive substances arise primarily during agricultural or chemical production processes and through trafficking, and subsequently affect the environment through post-consumption waste and the health burden associated with treatments for substance use.[39] These processes lead to various environmental consequences, including air pollution, contamination and depletion of water resources, soil degradation, energy consumption, greenhouse gas emissions, and deforestation. Although the overall contribution of these impacts to the total environmental burden appears limited at the global level, they can exert significant pressure on ecosystems and local communities, particularly in regions where production is concentrated.[40]

2.3.1. Environmental Damage Caused by Drug/Stimulant Cultivation and Trafficking

The cultivation of plant-derived psychoactive substances often takes place in forested and ecologically sensitive areas, resulting in significant environmental consequences. The conversion of forest areas into agricultural land for coca, opium poppy, and cannabis production leads to deforestation, habitat fragmentation, and biodiversity

35 The increased demand for alcohol-related healthcare contributes to the environmental footprint of the healthcare sector by increasing healthcare activities such as hospital services, medication use, laboratory procedures, medical devices, and energy and water consumption. The indirect environmental costs associated with alcohol-related healthcare services should also be taken into account. For modeling of the carbon footprint of healthcare services in general, see Matthew J. Eckelman, Kathryn Lagasse, Stefanie N. B. Sullivan, and Jonathan D. Patz, "Modeling National Health Care System Carbon Footprints: Opportunities, Challenges and Recommendations," The Lancet Planetary Health 6, no. 9 (2022): e760-e766, https://pmc.ncbi.nlm.nih.gov/articles/PMC9541808/ (Accessed: 6 October 2026).

36 World Health Organization (WHO), "Alcohol," WHO Fact Sheet, https://www.who.int/news-room/fact-sheets/detail/alcohol (Accessed: 6 October 2026).

37 World Health Organization (WHO), Factsheet: Sustainable Development Goals (SDGs): Health Targets and Alcohol Consumption (Geneva: World Health Organization, n.d.), https://iris.who.int/server/api/core/bitstreams/1367a797-200e-4cc0-8914-3e9e3f8a28bd/content (Accessed: 6 October 2026).

38 United Nations Office on Drugs and Crime (UNODC), World Drug Report 2022, Booklet 5: Drugs and the Environment, Vienna, 2022, https:// www.unodc.org/res/wdr2022/MS/WDR22_Booklet_5.pdf (Accessed: 7 October 2026).

39 United Nations Office on Drugs and Crime (UNODC), "The Impact of Drugs on the Environment in Europe," World Drug Report 2025, 2025, https://www.unodc.org/documents/data-and-analysis/WDR2025/WDR25_B2_Environmental_crime_draft.pdf (Accessed: 7 October 2026).

40 World Drug Report2022, Booklet 5: Drugs and the Environment, pp. 21-22.

loss, while the intensive use of fertilisers, pesticides, and irrigation practices also places pressure on soil and water resources. Indeed, intensive cannabis cultivation in Morocco's Rif region has been reported to exacerbate water scarcity and biodiversity loss, while excessive irrigation in certain opium-producing areas of Afghanistan has been reported to cause soil salinisation and declines in groundwater levels. These impacts contribute not only to the degradation of local ecosystems but also to the intensification of climate change through the loss of carbon sinks.[41]

Deforestation can be considered one of the most visible environmental impacts of drug production associated with the cultivation of plant-derived psychotropic substances. In Colombia, where forests cover approximately 70% of the country's territory, a significant proportion of forest loss has been concentrated in areas where coca cultivation has expanded. Many forested areas that were difficult to access during the conflict period became more vulnerable to agricultural expansion, land occupation, and coca cultivation following the peace process. As a result, each hectare of coca cultivation has been associated with a greater extent of deforestation.[42] In the "Golden Triangle Region" of Southeast Asia, encompassing Thailand, Laos, and Myanmar, opium poppy cultivation is identified as one of the activities contributing to deforestation. As poppy cultivation rapidly depletes soil fertility, production shifts to new areas within a few years of forest clearance, leading to the continuous conversion of additional forest areas into agricultural land.[43]

Trafficking is also considered one of the causes of deforestation. For instance, psychoactive substance trafficking in forests of critical importance for biodiversity in Central America accelerates deforestation through the establishment of clandestine airstrips, illicit routes, and logistical networks. Moreover, the channelling of proceeds from psychoactive substances into activities such as land acquisition, cattle ranching, and palm oil production leads to the conversion of protected forests into agricultural land and pasture. In addition, although anti-trafficking operations may be successful, they can cause activities to shift to new and more remote forested areas, thereby facilitating the geographical spread of deforestation.[44] In Nigeria, an observable relationship also exists between cannabis cultivation and deforestation. Although cannabis cultivation areas account for only approximately 0.02% of the country's total arable land, 39% of the cannabis farms identified in 2019 had been established in areas deforested in the same year.[45]

When examining the climate impacts of substance production, data on indoor cultivation are particularly noteworthy. Carbon footprint analyses indicate that the cultivation of psychotropic plants can entail substantial environmental costs. In particular, indoor cannabis cultivation generates approximately 2,300–5,200 kg CO_2e in emissions per kilogram due to intensive energy consumption, whereas this figure ranges from 22.7 to 326.6 kg CO_2e for outdoor cultivation. In cocaine production, agricultural activities and chemical processes generate substantial emissions, and when forests are cleared for coca cultivation, the carbon footprint can reach 4–6 tonnes of CO_2e per kilogram.[46]

In assessing environmental impacts, consideration should be given not only to the size of the affected area but also to the nature of the pollution, the duration of exposure, and the characteristics of the population affected. Production activities in ecologically sensitive areas, in particular, may affect local communities' access to water, land, and safe living environments, in addition to causing the depletion of natural resources. However, data on the environmental consequences of illicit production and trafficking are not equally comprehensive across all regions. Therefore, regional differences, the strength of the available evidence, and existing knowledge gaps should be considered together when assessing the magnitude of environmental impacts.[47]

41 World Drug Report 2022, Booklet 5: Drugs and the Environment, pp. 16–22, 33.

42 Erika M. Murillo-Sandoval, Matthew C. Hansen, Claudia M. Palacio-Castañeda, Diego Armenteras, and Nelly Rodríguez Eraso, "The End of Gunpoint Conservation: Forest Disturbance after the Colombian Peace Agreement," Environmental Research Letters 15, no. 10 (2020): 104033, https://doi.org/10.1088/1748-9326/abb331.

43 United Nations International Drug Control Programme (UNDCP), "Environmental Effects of Illicit Crop Cultivation," in World Drug Report 1997 (Oxford: Oxford University Press for UNDCP, 1997), https://www.unodc.org/documents/wdr/world_drug_report_1997/CH4/BOX4AB.pdf (Accessed: 7 October 2026).

44 Daniel Powell, "Narco-Deforestation: Linking Drug Policy and Forest Conservation," Our World (United Nations University), 6 February 2014, https:// ourworld.unu.edu/en/narco-deforestation-linking-drug-policy-and-forest-conservation (Accessed: 7 October 2026).

45 World Drug Report 2022, Booklet 5: Drugs and the Environment, pp. 33–34.

46 World Drug Report 2022, Booklet 5: Drugs and the Environment, pp. 37–38.

47 World Drug Report 2022, Booklet 5: Drugs and the Environment, pp. 20–21.

2.3.2. Environmental Damage Arising from Psychoactive Substance Use and the Cost of the Health Burden

Although the environmental impacts of psychoactive substance use are less visible than those associated with production and trafficking activities, they constitute a research area of growing importance, particularly with regard to aquatic ecosystems. Waste generated by substance production, use, and intervention activities may constitute hazardous waste. Solvents, acids, and other chemicals originating from laboratories, as well as used syringes and contaminated materials, can cause soil and water pollution if not disposed of properly. Chemical waste originating from illicit production sites should be assessed not only in terms of environmental pollution but also from the perspective of local environmental health. Depending on the nature of the contamination and the conditions of exposure, waste released into soil, surface water, or groundwater may pose risks to communities living near production sites, workers, and response teams. In these areas, it is important not only to collect the waste but also to determine the spread of contamination, conduct the necessary environmental sampling, assess individuals at risk, and safely remediate the site. Indeed, studies conducted at waste sites associated with synthetic psychoactive substance production in Europe have shown that certain production wastes and related compounds can be detected in environmental samples. Waste generated particularly by synthetic substance production has been reported to exhibit high toxicity and persist in the environment for extended periods. Therefore, waste associated with psychoactive substances should be regarded not only as a security or health issue but also as a waste management and environmental protection issue.[48]

The production of synthetic psychoactive substances also causes chemical environmental degradation. Numerous chemicals are used in the processing of these substances. Chemical waste generated particularly during the production of substances such as cocaine, methamphetamine, and MDMA is often not disposed of in accordance with environmental regulations and may be released into soil, surface water, or groundwater. The illicit production of MDMA, amphetamine, and methamphetamine, which are produced extensively in the Netherlands and Belgium, generates very large quantities of chemical waste; it is estimated that approximately 25–43 kg of liquid chemical waste is generated for every 1 kg of substance produced.[49] When released into the environment, this waste poses significant environmental risks. This can lead to deterioration in water quality, toxic effects on living organisms, and long-term environmental contamination.

Psychoactive substances and their metabolites, which are excreted from the human body without being completely broken down, can enter wastewater through sewerage systems and reach rivers, lakes, and other aquatic environments when they are not fully removed during treatment processes. In this context, wastewater monitoring studies are gaining importance as a field at the intersection of environmental surveillance and public health research. Measuring drugs and their metabolites in wastewater can contribute to the indirect assessment of trends in substance use within a given community. However, these measurements alone do not provide definitive conclusions regarding individual substance use, the diagnosis of addiction, or environmental health risks. Environmental sampling results need to be interpreted in conjunction with water quality data, treatment processes, and appropriate risk assessments. Research indicates that certain substances and their metabolites can still be present in aquatic environments after treatment, although the long-term effects on natural ecosystems require further investigation.[50] Current findings indicate that even these substances, which are generally present in the environment at low concentrations, can cause behavioural and physiological changes in certain species. Studies conducted particularly on organisms such as trout, crayfish, zebrafish, and zebra mussels suggest that changes may occur in locomotion, feeding behaviour, stress responses, reproductive functions, and metabolic processes. However, most existing research is based on laboratory experiments, and significant knowledge gaps remain regarding how these effects may accumulate over time in natural ecosystems, alter interspecies interactions, and affect ecosystem functions.[51]

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48 European Union Drugs Agency (EUDA), European Drug Report 2026: Trends and Developments (Luxembourg: Publications Office of the European Union, 2026), https://www.euda.europa.eu/publications/european-drug-report/2026_en (Accessed: 7 October 2026).

49 Thomas L. ter Laak and Erik Emke, Environmental Impact of Synthetic Drug Production: Analysis of Groundwater Samples for Contaminants Derived from Illicit Synthetic Drug Production Waste (Lisbon: European Union Drugs Agency [EUDA], 2023), https://www.euda.europa.eu/drugs-library/ environmental-impact-synthetic-drug-production-analysis-groundwater-samples-contaminants-derived-illicit-synthetic-drug-production-waste_en (Accessed: 7 October 2026).

50 Mei, X., et al. (2022). Origin, transport and ecological risk assessment of illicit drugs in the environment—A review. Chemosphere. https://doi.org/10.1016/j.chemosphere.2022.137091.

51 World Drug Report 2022, Booklet 5: Drugs and the Environment, pp.71-73.

In addition, various types of waste may be released into the environment as a result of psychoactive substance use. Used syringes, plastic packaging, foil fragments, filters, capsules, and other consumption equipment should also be considered a significant source of waste in urban environments.[52] Syringes, needles, test kits, protective equipment, and other medical consumables can increase the medical waste burden when they are not collected properly. Therefore, it should be taken into account that free medical supplies distributed as part of harm reduction strategies also contribute to the waste burden. Consequently, adopting a substance addiction prevention strategy rather than a harm reduction strategy is critical for minimising environmental impacts and protecting planetary health.

Considering the health burden of substance addiction, the indirect environmental costs of this burden also warrant attention. Globally, approximately 63 million people were reported to have experienced drug use disorders in 2024, while drug-related deaths in 2023 were reported to have approached half a million. The fact that a substantial proportion of the 14.3 million people who inject drugs are living with HIV and hepatitis C demonstrates that the health burden associated with psychoactive substances is not limited to addiction treatment but also encompasses infectious diseases, chronic liver diseases, emergency department services, intensive care, and long-term healthcare expenditure. However, only one in every 12 people living with drug use disorders is able to access treatment, indicating that the pressure on healthcare systems is likely to persist.[53] From an environmental perspective, this health burden generates indirect environmental costs. Increased hospital admissions associated with substance use, pharmaceutical consumption, laboratory testing, treatment of infections, and long-term care services increase the healthcare sector's consumption of energy, water, and medical supplies. All these harms should not be viewed solely through the lens of the human environment but should also be assessed through the One Health approach.

When substance addiction is considered a social determinant of health, it should also be recognised as an indicator that a community may be more vulnerable to environmental risks. In the context of climate change, one of the most significant challenges of the present and the future, factors such as substance addiction that increase vulnerability to climate change must be addressed in order to build healthy, safe, and resilient communities.

2.4. Digital Addictions and Emerging Environmental Risks

Digital technologies offer significant opportunities in many areas of everyday life. However, the use of these services relies on a physical system comprising user devices, communication networks, data centres, storage systems, and cooling infrastructure. With the widespread adoption of digital technologies, the electricity, water, and hardware requirements of this infrastructure, as well as the volume of electronic waste generated at the end of its service life, have continued to increase, thereby exerting a growing environmental impact.

From the perspective of digital addictions, environmental impacts can be assessed in terms of the duration, intensity, and nature of use, as well as the digital design features that shape such use. Uncontrolled, repetitive, and prolonged use entails greater volumes of content viewed, video streaming, gaming sessions, data processing, and artificial intelligence interactions. Features designed to sustain user engagement, such as infinite scrolling, autoplay, personalised recommendations, notifications, and reward mechanisms, also play a role in perpetuating these patterns of use. In this context, the environmental dimension of digital addictions can be examined through the energy, water, hardware, and infrastructure requirements associated with data centres, social media, digital games, and artificial intelligence use.

2.4.1. Environmental Impact of Data Centres

Data centres operating behind digital services constitute one of the core physical infrastructures underpinning these services. The storage and transmission of social media content, the operation of online games, and the training and deployment of artificial intelligence models, as well as the provision of cloud services, take place

52 European Union Drugs Agency (EUDA), European Drug Report 2026: Trends and Developments (Luxembourg: Publications Office of the European Union, 2026), pp. 210-211, https://www.euda.europa.eu/publications/european-drug-report/2026_en (Accessed: 7 October 2026).

53 United Nations Office on Drugs and Crime (UNODC), World Drug Report 2026: Special Points of Interest (New York: United Nations, 2026), pp. 25-26, https://www.unodc.org/documents/data-and-analysis/WDR_2026/WDR26_Special_points_of_interest.pdf, (Accessed: 7 October 2026).



largely within these centres. Therefore, the widespread adoption of digital technologies and the increasing intensity of their use are also significant in terms of the energy and resource requirements of data centres.

Electricity demand from data centres has increased rapidly in recent years. According to the International Energy Agency's latest assessment, global electricity consumption by data centres reached approximately 485 TWh in 2025. This figure is expected to double by 2030, accounting for approximately 3% of global electricity consumption. While total electricity consumption by data centres increased by 17% in 2025, the increase in AI-focused data centres reached 50%.[54]

Studies conducted primarily in the United States also demonstrate the scale of this growth. According to an assessment by Lawrence Berkeley National Laboratory, data centres in the United States consumed 176 TWh of electricity in 2023, accounting for 4.4% of the country's total electricity consumption. Depending on different technology and usage scenarios, this consumption is projected to reach between 325 and 580 TWh in 2028. This range corresponds to 6.7% to 12% of US electricity consumption.[55]

Of course, it is not possible to attribute all of this growth to digital addictions. Areas such as cloud computing and the digitalisation of corporate and public services also increase demand for data centres. From the perspective of digital addiction, the issue that warrants attention is the possibility that uncontrolled and repetitive use may be one of the factors that adversely affect the environment. Indeed, although advances in technological efficiency aim to reduce energy use, they do not necessarily translate into a reduction in total energy consumption. This is because increased accessibility can lead to more widespread use and the emergence of new digital services, thereby increasing environmental impacts once again. This phenomenon is referred to as the *rebound effect* in the digitalisation literature.[56]

The design of platforms is also important in the relationship between digital addiction and the environmental impact of data centres. In its 2026 Digital Services Act investigation concerning Instagram and Facebook, the European Commission examined the addictive design features of these platforms, including infinite scrolling, autoplay, instant notifications, and highly personalised recommendation systems. In its preliminary assessment, the Commission stated that Meta had not sufficiently considered the risks posed by these design features to users' physical and psychological well-being.[57]

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54 International Energy Agency, *Key Questions on Energy and AI* (IEA, 2026), Accessed: 9 October 2026, https://www.iea.org/reports/key-questions-on-energy-and-ai.

55 Arman Shehabi et al., *2024 United States Data Center Energy Usage Report* (Lawrence Berkeley National Laboratory, 2024), https://doi.org/10.71468/P1WC7Q.

56 H. R. Peng and X. F. Qin, "Digitalization as a Trigger for a Rebound Effect of Electricity Use," *Energy* 300 (2024): 131585.

57 European Commission, "Commission Preliminarily Finds the Addictive Design of Instagram and Facebook in Breach of the Digital Services Act," 10 July 2026, accessed: 9 October 2026, https://digital-strategy.ec.europa.eu/en/news/commission-preliminarily-finds-addictive-design-instagram-and-facebook-breach-digital-services-act.

The environmental impact that digital addictions may generate through data centres should be assessed in terms of cumulative and large-scale use. Prolonged online activity by large numbers of users, continuous video streaming, online gaming sessions, and repetitive use of artificial intelligence can increase the overall demand for digital services.[58]

While existing studies clearly demonstrate the growing energy and resource requirements of data centres, they have not yet been able to directly measure the share of this demand attributable to problematic or addiction-level use. Therefore, the promotion of healthy digital use should be addressed alongside platform design, processing and data intensity, data centre efficiency, and the environmental transparency of technology companies.

2.4.2. Gaming, Social Media, and Artificial Intelligence

Digital games, social media platforms, and artificial intelligence applications are among the digital technologies that are occupying an increasingly prominent place in everyday life. These technologies affect the environment through various factors, including energy consumption by users' devices, data centres, communication networks, the production of digital devices, and electronic waste generated at the end of their service life. Therefore, understanding the environmental dimension of activities carried out in digital environments requires an assessment of user behaviour and the technological infrastructure that enables these activities.

When considered in terms of addiction and problematic use behaviours, the duration, frequency, and intensity of engagement with digital technologies become important. Prolonged and repetitive patterns of use can affect energy and resource consumption by increasing demand for digital services. However, patterns of use, infrastructure requirements, and environmental impacts differ among social media, digital games, and artificial intelligence applications. Therefore, it is important to examine these technologies separately in terms of addiction and environmental sustainability.

2.4.2.1. Social Media

The environmental impact of social media platforms should be assessed in conjunction with the ways in which users interact with content and the digital infrastructure that enables these interactions. In particular, the widespread adoption of video-based content has increased the share of social media use in data traffic. As of the end of 2025, video content consumption accounted for approximately 75% of global mobile data traffic.[59] An examination of four European mobile networks also found that videos originating from social media accounted for approximately 70% to 80% of mobile video traffic on smartphones.[60] These findings demonstrate the scale of data usage attributable particularly to short-form social media videos on smartphones.

The environmental dimension of social media use in relation to addiction arises through the frequency, duration, and repetitive nature of use. Short-form videos, autoplay, infinite content feeds, instant notifications, and personalised recommendations continuously present users with new stimuli, making it more difficult to disengage from the platform. In its preliminary assessment concerning TikTok in February 2026, the European Commission identified infinite scrolling, autoplay, instant notifications, and highly personalised recommendation systems as elements of the platform's addictive design. The Commission also indicated that the frequency with which users open the application and the time children spend on the platform at night are among the indicators of problematic use.[61] Similarly, it was stated that Meta had not sufficiently assessed the negative effects of addictive design.[62]

Individual and demographic characteristics, such as age, social environment, and psychological needs, also influence the increase in social media use. Therefore, when assessing the environmental dimension of social media addiction, the usage patterns of different user groups must also be taken into account. For example, while social media use among older adults can provide significant benefits in maintaining family and social ties,

58 *International Energy Agency, Key Questions on Energy and AI.*

59 Ericsson, *Mobile Network Traffic Q2 2026*, Ericsson Mobility Report (2026), accessed: 9 October 2026, https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/mobile-traffic-update.

60 Ericsson, "Short-Form Dominates Video Traffic," *Ericsson Mobility Report*, 20 November 2025, accessed: 9 October 2026, https://www.ericsson.com/ en/reports-and-papers/mobility-report/articles/short-form-dominates-video-traffic.

61 European Commission, "Commission Preliminarily Finds TikTok's Addictive Design in Breach of the Digital Services Act," 6 February 2026, accessed: 9 October 2026, https://digital-strategy.ec.europa.eu/en/news/commission-preliminarily-finds-tiktoks-addictive-design-breach-digital-services-act.

62 European Commission, "Commission Preliminarily Finds the Addictive Design of Instagram and Facebook."

it may develop into problematic patterns of use in certain groups in association with loneliness, social isolation, psychological needs, and algorithmic reinforcement mechanisms. Studies on social media addiction among older adults indicate that the narrowing of social networks after retirement, loneliness, the need for emotional support, and the continuously interactive nature of digital platforms may contribute to excessive use.[63]

When these findings are assessed from an environmental perspective, it becomes evident that the increase in social media use is part of a broader digital ecosystem that influences demand for data transmission, storage, and processing capacity on a scale involving billions of users. Assessing problematic social media use in terms of duration of use, interaction intensity, and usage patterns across different demographic groups is important for a better understanding of the environmental impacts of digital addictions.

The relationship between social media and environmental sustainability should be assessed in terms of the aggregate digital demand generated by billions of users, rather than the impact of individual pieces of content or individual usage. Existing literature indicates that digital content consumption relies on physical infrastructure comprising devices, communication networks, and data centres, and that design features intended to increase user engagement can influence the risk of problematic use.[64] However, studies directly measuring the share of problematic social media use in total energy consumption, data traffic, and carbon footprint remain limited. Future research that jointly examines user behaviour, platform design, and the environmental impacts of digital infrastructure would contribute to a more comprehensive understanding of the environmental dimension of social media addiction.

2.4.2.2. Digital Games

The environmental impact of digital games can be assessed by considering electricity consumption during gameplay, data transmission required to support gaming, and the life cycle of hardware. The processing power of gaming computers and consoles, display specifications, game software, and gaming duration can significantly affect energy consumption. A study conducted by Lawrence Berkeley National Laboratory noted that energy use varies considerably depending on both hardware specifications and the game being played. Accordingly, factors such as high processing power, graphics quality, and high-resolution displays are among the main determinants of energy consumption in gaming.[65]

The duration of gameplay is an important variable in determining the environmental impact of gaming. Problematic gaming behaviour is characterised by above-average gaming duration and a decline in functioning in daily life.[66] Increased gaming time, a tendency towards online gaming, and psychological stress are among the characteristics associated with gaming addiction.[67] An analysis published by PlayersTime in 2026 estimated annual emissions of approximately 261 kg CO_2 for a high-use scenario involving around 32 hours of gaming per week on a high-performance gaming computer, compared with 81 kg CO_2 under an average-use scenario. Similarly, calculations indicate that the annual energy-related carbon footprint of intensive-use scenarios for certain high-performance gaming consoles can exceed 100 kg CO_2.[68] These findings indicate that gaming duration and the energy requirements of the devices used can play a significant role in the overall environmental burden.

Long and repetitive gaming sessions may increase total usage time, thereby causing the negative environmental impact to grow over time. The user-side carbon footprints of Counter-Strike and Dota 2, among the most-played

63 Jiaoling Huang et al., "Associations Between Social Media Use and Anxiety and Depression Among Older Adults: Cross-Sectional Study," *JMIR Aging* 8 (2025): e71712, https://doi.org/10.2196/71712; Y. Jia, T. Liu, and Y. Yang, "The Relationship Between Real-Life Social Support and Internet Addiction Among the Elderly in China," *Frontiers in Public Health* 10 (2022): 981307, https://doi.org/10.3389/fpubh.2022.981307; Zhaoxue Li, Xiaoyong Yu, and Kan Tian, "Algorithm-Associated Digital Addiction Among Older Adults: Mechanisms and Public Health Implications for Healthy Aging," *Frontiers in Public Health* 13 (2026): 1746304, https://doi.org/10.3389/fpubh.2025.1746304.

64 R. Istrate et al., "The Environmental Sustainability of Digital Content Consumption," *Nature Communications* 15 (2024): 3724, https://doi.org/10.1038/ s41467-024-47621-w; European Commission, "Commission Preliminarily Finds TikTok's Addictive Design"; European Commission, "Commission Preliminarily Finds the Addictive Design of Instagram and Facebook."

65 Evan Mills et al., "Toward Greener Gaming: Estimating National Energy Use and Energy Efficiency Potential," *The Computer Games Journal* 8, no. 3 (2019): 157–178, https://doi.org/10.1007/s40869-019-00084-2.

66 Niko Männikkö et al., "Problematic Gaming Behaviour and Health-Related Outcomes: A Systematic Review and Meta-Analysis," *Journal of Health Psychology* 25, no. 1 (2020): 67–81, https://doi.org/10.1177/1359105317740414.

67 P. Limone, B. Ragni, and G. A. Toto, "The Epidemiology and Effects of Video Game Addiction: A Systematic Review and Meta-Analysis," *Acta Psychologica* 241 (2023): 104047, https://doi.org/10.1016/j.actpsy.2023.104047.

68 A. Dimitrova, "Playtime vs. Planet: The Electricity Cost and Carbon Footprint of Modern Gaming," *PlayersTime*, 2026.

games globally in 2024, were modelled in accordance with the principles of ISO 14067. Approximately 75% of the emissions within the scope of the model originated from electricity consumed during gameplay.[69]

In addition to usage-related emissions associated with gaming duration, hardware production is also a significant component of the overall footprint. Gaming computers, consoles, displays, and graphics cards are part of the electronic product life cycle, which extends from raw material extraction and manufacturing to the end of their service life. Replacing or upgrading hardware to meet higher performance requirements, or its eventual disposal at the end of its service life, can increase environmental impacts. The modelling study mentioned above also showed that computer manufacturing accounted for approximately one-quarter of the total modelled emissions.[70] These data indicate that the hardware dimension should not be overlooked when considering problematic gaming behaviour.

This issue is addressed as part of the global electronic waste problem. According to the Global E-waste Monitor, prepared by the ITU and UNITAR, 62 million tonnes of electronic waste were generated worldwide in 2022, and only 22.3% of this amount was documented as having been collected and recycled in an environmentally sound manner. If current trends continue, the global volume of electronic waste is expected to reach 82 million tonnes by 2030.[71] The report identifies technological advances, rising consumption, limited repair options, and shorter product life cycles among the factors contributing to the growth of electronic waste. Although these figures are not specific to gaming devices, they highlight the growing resource and waste challenges associated with the global electronic product life cycle, which also encompasses gaming hardware.



A detailed material and life cycle assessment of the PlayStation 4 estimated that the manufacturing and transportation of a single console were associated with approximately 89 kg of CO_2 emissions. Calculations based on approximately 100 million devices indicated that the total carbon footprint associated with manufacturing and transportation could reach approximately 8.9 million tonnes of CO_2.[72] In assessments of sustainability in the gaming industry, avoiding unnecessary device replacement, improving repairability, and extending product service life are also among the key practices highlighted for reducing electronic waste.[73]

Current literature on the environmental impact of gaming is thus moving towards a broader life cycle perspective that extends beyond the electricity consumed by the player. The manufacturing and energy efficiency of the device used, whether the game is played locally or via the cloud, data centre and network infrastructure, gaming duration, device service life, and electronic waste generated at the end of use should all be assessed together. The environmental impact of the same game can vary considerably depending on the devices used, the countries in which it is played, and patterns of use.[74]

The fundamental research question from an addiction perspective also emerges at this point. Existing addiction literature highlights prolonged, frequent, and repetitive use as prominent features of problematic gaming behaviour, while environmental literature shows that gaming duration, device power, and hardware manufacturing affect the overall environmental footprint of gaming.[75] Therefore, digital gaming addiction can be addressed as a behavioural factor that negatively affects the environment through problematic and prolonged use.

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69 David Medina, "Carbon Footprint of Online Multiplayer Games," *Games and Culture*, published online 8 May 2026, https://doi.org/10.1177/15554120261448902.

70 Medina, "Carbon Footprint of Online Multiplayer Games."

71 International Telecommunication Union and United Nations Institute for Training and Research, *The Global E-Waste Monitor 2024* (ITU and UNITAR, 2024), accessed: 9 October 2026, https://www.itu.int/en/ITU-D/Environment/Pages/Publications/The-Global-E-waste-Monitor-2024.aspx.

72 L. Gordon, "The Environmental Impact of a PlayStation 4," *The Verge*, 2019.

73 Charlie Fletcher, "Game Changers: Achieving Sustainability in the Video Game Industry," *Earth.Org*, 9 January 2024, accessed: 9 October 2026, https://earth.org/sustainability-and-the-video-gaming-industry/.

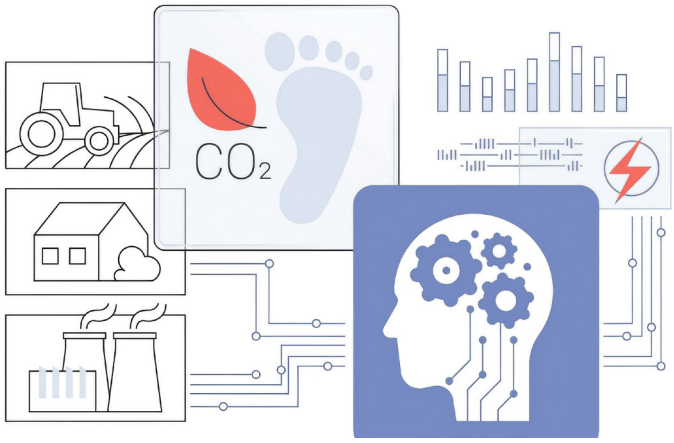
74 Mills et al., "Toward Greener Gaming"; Medina, "Carbon Footprint of Online Multiplayer Games."

75 Limone, Ragni and Toto, "The Epidemiology and Effects of Video Game Addiction"; Mills et al., "Toward Greener Gaming"; Medina, "Carbon Footprint of Online Multiplayer Games."

Reducing the environmental impact of digital games requires a combined approach involving measures at both the user and system levels, including preventing problematic gaming behaviour, designing energy-efficient hardware and software, extending device service life, improving repairability, and increasing the efficiency of cloud infrastructure. In the future, studies assessing gaming duration, device energy consumption, cloud and network use, hardware replacement behaviours, and indicators of gaming disorder within the same sample could enable a more accurate determination of the additional environmental burden associated with addiction.

2.4.2.3. Artificial Intelligence

The rapid integration of generative artificial intelligence into everyday life has added a new dimension to the relationship between digital addictions and environmental resource use. Chatbots, AI-powered search tools, and image and video generation tools are being used with increasing frequency and becoming more widespread. Alongside this expansion, research has begun to investigate whether patterns of excessive use that negatively affect functioning are emerging among some users. Problematic AI use is not yet an established clinical diagnosis. In the existing literature, it is addressed as a behavioural pattern that may be associated with impaired functioning, psychological distress, and loss of control over use.[76] Certain features of AI chatbots should be considered in terms of their potential to increase the risk of addiction. Indeed, their ability to provide immediate responses, personalise conversations, and exhibit human-like communication characteristics may encourage prolonged interaction.[77]



The environmental impact of artificial intelligence use arises from both its development and its use. The training of large AI models requires high-performance processors, data centres, and cooling systems. Energy consumption also becomes significant when generating responses to user requests. Recent systematic reviews of the electricity demand of large language models emphasise the need to assess training and response-generation processes together.[78]

The energy requirements of AI operations vary considerably depending on the type of task. The International Energy Agency reports that tasks such as video generation or advanced research can require hundreds or even thousands of times more energy than simple text generation.[79]

The environmental impact of AI infrastructure extends beyond electricity consumption. A study modelling the expansion of AI servers in the United States over the 2024–2030 period projects that, depending on different growth scenarios, the annual water footprint could range from 731 to 1,125 million m^3, with additional annual emissions of 24 to 44 million tonnes of CO_2.[80]

Problematic use may take the form of prolonged interactions, repeated generation of similar requests, or intensive use of the system for emotional support and social interaction. Such patterns have the potential to increase the environmental footprint during processing. The environmental impact of use may become more pronounced when tasks such as image and video generation are preferred.

76 Octavian Vasiliu, "Problematic Use of Generative Artificial Intelligence Chatbots: Current Stage of Conceptual and Clinical Understanding," *Frontiers in Public Health* 14 (2026): 1816917, https://doi.org/10.3389/fpubh.2026.1816917.

77 Vasiliu, "Problematic Use of Generative Artificial Intelligence Chatbots."

78 Z. Ji and M. Jiang, "A Systematic Review of Electricity Demand for Large Language Models: Evaluations, Challenges, and Solutions," *Renewable and Sustainable Energy Reviews* 225 (2026): 116159, https://doi.org/10.1016/j.rser.2025.116159.

79 International Energy Agency, *Key Questions on Energy and AI*.

80 T. Xiao et al., "Environmental Impact and Net-Zero Pathways for Sustainable Artificial Intelligence Servers in the USA," *Nature Sustainability* 8 (2025): 1541–1553, https://doi.org/10.1038/s41893-025-01681-y.

To establish the environmental impact of problematic AI use, user behaviour and the type of processing involved need to be assessed together. Examining indicators such as the number of daily interactions, session duration, and the types of content generated alongside criteria for problematic use can contribute to determining the environmental impact of such use. However, environmental responsibility should not be reduced solely to user behaviour. Model and system design, efficiency, and companies' transparency regarding their energy and water consumption also determine the overall environmental impact. Studies examining the psychological and behavioural characteristics of problematic AI use and the energy and resource requirements of AI infrastructure separately are becoming increasingly numerous. Research directly linking these two areas, however, remains at an early stage. Measuring this relationship is expected to become an important area of research in the coming period, particularly in the joint assessment of AI use in terms of addiction and environmental impact.

2.5. Environmental Impacts of the Gambling Industry

Although research on the gambling industry in relation to gambling addiction has primarily focused on social and economic costs, the industry's environmental impacts and its relationship with climate change have also begun to feature in reports published in recent years.[81] The gambling industry consumes large amounts of energy to maintain the 24-hour operation of physical venues worldwide,[82] while online platforms also require substantial energy to maintain data centres, support real-time transactions, and keep extensive server networks running continuously.[83] This substantial energy consumption increases the industry's environmental footprint.

An example illustrating the scale of energy consumption by physical casinos is the consumption rate of a casino in Las Vegas. Such a casino consumes between 15,000 and 18,000 kWh of electricity per day, an amount equivalent to the electricity required to supply an average of 1,500 to 1,800 households.[84] In addition, casinos and their associated hotel and restaurant businesses engage in activities that consume high levels of energy and generate substantial amounts of waste and wastewater.[85] For example, the average daily water consumption per occupied hotel room is 825 litres. In terms of energy use, casinos are reported to consume five times more energy per square metre than large hospitals. Consequently, casinos are highlighted as having a high carbon footprint due to their 24-hour operation of lighting, heating and cooling systems,[86] slot machines, and hotel services.[87] Furthermore, since physical gambling is closely associated with hotels, restaurants, entertainment, shopping, transport, and other tourism services, cities hosting gambling establishments also encompass urban consumption systems that demand substantial amounts of energy, water, food, materials, and transport services. Therefore, the environmental impacts of the gambling industry can be examined not only in terms of the direct consumption of physical casinos but also across the entire value and supply chain.[88] For example, although the gambling sector, which forms the backbone of Macao's economy, does not consume large amounts of water directly, it generates substantial indirect water consumption through the goods and services it uses. A study on this subject demonstrates that the environmental impact of the sector cannot be measured solely by the water used at its facilities; embedded water use throughout the supply chain must also be taken into account.[89]

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81 European Gaming and Betting Association (EGBA), Sustainability Report 2025: Creating Social Value Through Safer Play and Responsible Operations (Brussels: EGBA, 2025), https://www.egba.eu/uploads/2025/07/250709-EGBA-Annual-Sustainability-Report-2025.pdf (Accessed: 27 August 2026).; Deloitte and Responsible Gambling Council (RGC), Beating the Odds: The Imperative of ESG for the Future of Gambling (August 2024), https://responsiblegambling.org/wp-content/uploads/Beating-the-Odds-The-Imperative-of-ESG-for-the-Future-of-Gambling_Aug-2024.pdf (Accessed: 27 August 2026).

82 Saving Tool, "The Environmental Cost of Gambling: How Casinos Are Going Green," https://savingtool.co.uk/blog/the-environmental-cost-of-gambling-how-casinos-are-going-green/ (Accessed: 27 August 2026).

83 Intelligent Living, "Green Gaming: The Online Casino Industry's Environmental Impact," https://www.intelligentliving.co/green-gaming-online-casino-industry/ (Accessed: 27 August 2026).

84 Las Vegas casinos consume up to 5,600 MW of energy per day in total, which is approximately equivalent to Myanmar's annual energy generation capacity. See. Saving Tool, "The Environmental Cost of Gambling: How Casinos Are Going Green," https://savingtool.co.uk/blog/the-environmental-cost-of-gambling-how-casinos-are-going-green/ (accessed: 27 August 2026).

85 A study on tribal casinos in the United States highlights, as an example, that commercial businesses in California account for approximately half of the state's total waste disposed of collectively.

86 Climate control refers to HVAC (Heating, Ventilation and Air Conditioning) systems, encompassing heating, ventilation, and air conditioning/cooling systems

87 United States Environmental Protection Agency (EPA), "Tribal Casino Pollution Prevention Best Management Practices/ P2 Resource List", https://nepis.epa.gov/Exe/tiff2png.cgi/P10153HA.PNG?-r+75+-g+7+D%3A%5CZYFILES%5CINDEX%20DATA%5C06THRU10%5CTIFF%5C00002089%5CP10153HA.TIF , (Accessed: 27 August 2026).

88 Fan Cheong and Young-Hee Lee, "Developing an Environmental Management System for Evaluating Green Casino Hotels," Sustainability 13, no. 14 (2021): 7825, https://doi.org/10.3390/su13147825.

89 J. S. Li and G. Q. Chen, "Water Footprint Assessment for Service Sector: A Case Study of Gaming Industry in Water Scarce Macao," Ecological Indicators 47 (2014): 164-170, https://doi.org/10.1016/j.ecolind.2014.01.034.

Nevertheless, the environmental pressures generated by large-scale casino complexes that offer multiple services cannot be assessed solely in terms of water consumption. With regard to casinos and associated tourism activities, environmental risk factors can be examined from a public health perspective through issues such as the prevention of food- and waterborne diseases, the control of vector-borne diseases, waste management, and the reduction of noise and light pollution.[90] Furthermore, these activities can increase the movement of visitors and vehicles to the area, leading to higher traffic volumes. Transport-related greenhouse gas emissions and other air pollutant emissions resulting from increased traffic volumes can, in turn, place additional pressure on the environment and climate.[91]

The proposal to shift towards online gambling in order to reduce the share of energy consumed by physical casinos in the industry represents an environmental manifestation of harm reduction strategies, as the aim of this approach is not to eliminate gambling addiction and the resulting environmental harms entirely, but rather to reduce them. Accordingly, a range of recommendations has been put forward in this direction. However, as in other digital sectors, the online gambling industry consumes substantial amounts of energy to maintain data centres, support real-time transactions, and keep extensive server networks running continuously.[92]

Data centre energy consumption across all digital sectors, including the online gambling sector, whose share has been increasing over the years, accounts for approximately 1–2% of global electricity consumption, and this figure is projected to double by 2030. Moreover, while streaming platforms and e-commerce companies can benefit from centralised data centre infrastructure at the global level, online gambling operators often have to establish separate data processing and storage infrastructure in the jurisdictions in which they hold licences. Consequently, higher energy consumption by the online gambling industry and the resulting increase in its carbon footprint become inevitable.[93] Furthermore, the increased accessibility of casinos that have moved to the virtual environment contributes to an increase in gambling addiction and, consequently, the number of users.[94] The resulting rise in demand for energy and resources to support digital infrastructure demonstrates how our planet is being drawn into a vicious cycle in terms of environmental harm.

The environmental impact of online gambling is not limited to the energy consumption of data centres and the associated carbon footprint. Computers, displays, servers, network and communication equipment, payment terminals, cameras, and other electronic devices used to sustain the digital gambling ecosystem also generate environmental burdens through their production, use, replacement, and end-of-life waste. Therefore, the electronic waste dimension must also be taken into account when assessing the digitalisation of gambling. UNEP highlights that digitalisation increases electronic waste generation alongside energy and resource consumption, noting that the short service lives of electronic devices and low recycling rates exacerbate this burden.[95]

In conclusion, the shift of gambling activities from physical to digital environments does not eliminate environmental costs; rather, it changes their nature and form. On the one hand, increased energy demand and carbon emissions arise from data centres and digital infrastructure, while on the other, indirect resource consumption generated throughout the industry's supply chain continues. In particular, water consumption arising from the goods and services used by the industry can extend the pressure on water resources far beyond direct use. Therefore, when assessing the environmental impacts of the gambling industry, water stress, energy demand, supply chain burdens, water consumption, and the new energy and water requirements generated by the shift from physical to digital activities must be considered together. Otherwise, the environmental burden is not reduced but merely transferred to different areas in a different form. The true environmental cost of gambling

90 Ashley E. Milstead, Veronica A. H. W. Gibson and Sadie J. Ryan, "Scaling Night-Time Artificial Light and Disease Vector Interactions into Socio-Ecological Systems: A Conceptual Assessment," PLOS Global Public Health 3, no. 10 (2023), https://pmc.ncbi.nlm.nih.gov/articles/PMC10613543/ (Accessed: 5 October 2026); Robin Verma, Prveen, Rahul Kumar, Saurabh Tripathi, Arvind Chauhan, and Vikas Verma, "Vector-Borne Disease Risk Assessment in Hospitality Zones: A Case Study Approach," International Journal of Mosquito Research 12, no. 6 (2025): 51-53, https://doi.org/10.22271/23487941.2025.v12.i6a.870 .

91 J. S. Li and G. Q. Chen, "Water Footprint Assessment for Service Sector: A Case Study of Gaming Industry in Water Scarce Macao," Ecological Indicators 47 (2014): 164-170, https://doi.org/10.1016/j.ecolind.2014.01.034.

92 The proposed recommendations include the use of cryptocurrency and cloud-based infrastructure in online casinos, as well as the transition to renewable energy. See Intelligent Living, "Green Gaming: How the Online Casino Industry Can Reduce Its Carbon Footprint," https://www.intelligentliving.co/green-gaming-online-casino-industry/ (Accessed: 27 August 2026).

93 George, "Why Online Gambling Giants Are Racing to Build Green Data Centers," The Sustainable Data Center, 27 January 2026, https://www.greendatacenternews.org/data-center-design/why-online-gambling-giants-are-racing-to-build-green-data-centers/ (Accessed: 27 August 2026).

94 Türkiye Yeşilay Cemiyeti, Türkiye Kumar Raporu (İstanbul: Türkiye Yeşilay Cemiyeti, Eylül 2025), https://www.yesilay.org.tr/assets/uploads/pdf/turkiye-kumar-raporu-2025.pdf (Erişim Tarihi: 28 Ağustos 2026).

95 United Nations Environment Programme (UNEP), 2021, https://wedocs.unep.org/rest/api/core/ bitstreams/59e4dcd4-6483-4eca-939f-1e9575863eeb/content (Accessed: 6 October 2026).

thus emerges precisely at this point: water, energy, and natural resource consumption do not decrease; instead, these resources are displaced along supply chains and digital infrastructure, becoming less visible.

2.6. Greenwashing in Addiction Industries

Growing public awareness of environmental issues has led companies to communicate their environmental performance and sustainability goals to the public more intensively. However, the discrepancy between companies' environmental rhetoric and their actual practices has brought the concept of "greenwashing" to the fore. Greenwashing can generally occur when a company communicates in a way that portrays the environmental attributes of a company, product, or activity more favourably than they actually are, highlighting limited environmental gains while downplaying the broader environmental impacts of its operations.[96]

When examples from addiction industries are considered together, one of the fundamental problems with greenwashing and broader corporate social responsibility practices lies not so much in whether an environmental or social initiative has actually been undertaken, but rather in how that initiative is positioned in relation to the company's overall impact. A company may genuinely reduce its water consumption, undertake recycling activities, improve energy efficiency, or allocate resources to an environmental clean-up campaign. However, the existence of such activities does not eliminate the environmental costs arising throughout the entire life cycle of the products manufactured by the company.

Therefore, when evaluating greenwashing practices in addiction industries, several factors must be considered together: the environmental impact of the product throughout its entire life cycle; the magnitude of the environmental gain highlighted by the company relative to its total environmental impact; whether environmental claims have been independently verified; and how environmental activities are used in corporate reputation management or policy processes.

2.6.1. Greenwashing in the Tobacco Industry

One of the areas in which greenwashing practices are most clearly documented among addiction industries is the tobacco industry. The World Health Organization (WHO) explicitly defines the tobacco industry's attempts to downplay its environmental harms and position itself as an environmentally conscious sector as greenwashing. According to the WHO, through corporate social responsibility activities and environmental initiatives, the industry can divert attention from the impacts of tobacco cultivation, such as water pollution, soil degradation, and deforestation.[97]

This strategy becomes more apparent when the entire life cycle of tobacco products is taken into account. As demonstrated in previous sections, the environmental impacts of tobacco extend from the use of agricultural land and water, pesticide and fertiliser use, and deforestation during cultivation to energy and natural resource consumption and carbon emissions during manufacturing, and finally to plastic, electronic, and battery waste generated by cigarette butts, plastic filters, and e-cigarettes after consumption. Following consumption, cigarette filters containing plastic are a particularly significant source of waste. Plastic, electronic, and battery waste from e-cigarettes and other new-generation nicotine products adds to this burden. For this reason, the WHO draws particular attention to the contradiction between the tobacco industry's claims of environmental friendliness and the environ-mental harms generated throughout the life cycle of its products.[98] Greenwashing does not occur solely through corporate sustainability reports. Presenting tobacco products themselves in ways that evoke associations such as "natural," "organic," or "environmentally friendly" also falls within this scope.

The tobacco industry's environmental clean-up activities are also the subject of a similar debate. In campaigns aimed particularly at collecting cigarette butts, attributing environmental responsibility to consumer behaviour rather than to the product manufacturer can shift the framing of the problem away from its source. In this approach, the environmental problem is defined in terms of consumers failing to dispose of cigarette butts

96 Anastas Vangeli, Agnieszka Małecka, Maciej Mitręga and Gregor Pfajfar, "From Greenwashing to Green B2B Marketing: A Systematic Literature Review," *Industrial Marketing Management* 115 (2023): 281–299, https://doi.org/10.1016/j.indmarman.2023.10.002.

97 World Health Organization, "Tobacco Growing: Myth Buster," 23 May 2023, accessed: 27 August 2026, https://www.who.int/news-room/questions-and-answers/item/tobacco-growing--myth-buster

98 World Health Organization, "QGA: World No Tobacco Day 2022," 31 March 2022, Accessed: 27 August 2026, https://www.who.int/news-room/questions-and-answers/item/q-a-world-no-tobacco-day-2022.

properly, rather than the production of filters containing plastic that become waste in large quantities. As a result, the manufacturer's responsibility arising from product design and the environmental costs of products after consumption may be pushed into the background.

The supplement to the WHO's *Tobacco Control Playbook*, published in 2026, directly draws attention to this issue, emphasising that the tobacco industry can misrepresent its sustainability performance while causing environmental harm.[99] Therefore, greenwashing in the tobacco sector should be considered not merely an environmental communication problem, but also part of the industry's broader strategies to protect its corporate reputation and maintain social acceptance.



Figure 1: American Heart Association, 'Greenwashing' Image[100]

2.6.2. Greenwashing in the Alcohol Industry

The academic literature on greenwashing in the alcohol industry remains limited compared with that on the tobacco industry; however, studies directly examining environmental claims and the risk of greenwashing have begun to emerge in recent years. Researchers have also drawn attention to the extensive coverage of environmental issues in the corporate social responsibility and sustainability communications of major alcohol companies.[101]

The production of alcoholic beverages has an environmental footprint that extends from the cultivation of barley, grapes, and other agricultural raw materials to water and energy use at production facilities, glass and metal packaging, transportation, and post-consumption waste. In contrast, companies may choose to highlight more limited areas in their environmental communications, such as water conservation, lighter packaging, recycling, the use of renewable energy, or emission reductions at specific production facilities. Even when such gains are genuine, greenwashing concerns arise when environmental claims focusing on only one stage of production render the impacts of the product across its entire life cycle less visible.

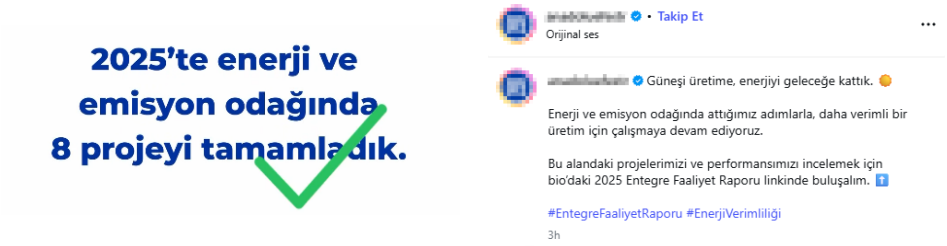


Figure 2: Social Media Post Illustrating the Alcohol Industry's Greenwashing Practices[102]

99 *World Health Organization Regional Office for Europe, Tobacco Control Playbook Supplement: Tobacco Industry Harms the Environment While Misrepresenting Its Sustainability (Copenhagen: WHO Regional Office for Europe, 2026), Accessed: 27 August 2026, https://www.who.int/europe/publications/i/item/WHO-EURO-2026-3700-43459-83015*

100 American Heart Association, "Greenwashing," görsel, *American Heart Association Newsroom*, Accessed: 27 August 2026, https://newsroom.heart.org/ file/greenwashing?action=

101 Megan Cook, Nathan Critchlow, Rachel O'Donnell, and Sarah MacLean, "Alcohol's Contribution to Climate Change and Other Environmental Degradation: A Call for Research," *Health Promotion International* 39, no. 1 (2024): daae004, https://doi.org/10.1093/heapro/daae004.

102 Example of an Instagram post, See Instagram, https://www.instagram.com/, accessed: 27 August 2026.

Such corporate sustainability posts do not, in themselves, constitute evidence of greenwashing, but they are among the examples that should be examined when evaluating companies' environmental communication strategies.

A study published in the journal *Sustainability* in 2026 examined the packaging of 5,982 alcoholic products available for sale in Australia in terms of environmental claims. The study found that 8% of the products contained at least one environmental claim. This proportion increased to 15% for beer products, while carbon-related claims were identified on 14% of the beers examined. The researchers also found that various environmental expressions, such as "sustainably made", "eco-friendly" and "carbon neutral/positive", were used on alcoholic beverage packaging. Such expressions are among the marketing claims that emphasise the environmental attributes of products. The researchers cautioned that environmental claims of this kind may pose a risk of greenwashing when they are not supported by adequate disclosure or verification.[103]



Figure 3: Examples of Environmental Claims and Recycling Information on Alcoholic Products[104]

This finding illustrates the central issue in the debate on greenwashing in the alcohol industry. The use of recycled materials in the packaging of an alcoholic beverage or a reduction in energy consumption at a production facility does not eliminate the product's overall environmental footprint, which extends from agricultural production and water use to energy consumption, glass packaging, and distribution. Therefore, highlighting a limited environmental attribute in a way that creates the impression that a product is generally "sustainable" or "environmentally friendly" is one of the key practices that should be examined in relation to greenwashing in the alcohol industry.

A similar picture emerges when the issue is considered in the context of broader corporate strategies. Academic studies examining corporate social responsibility activities in the alcohol industry have shown that corporate social responsibility can be used as a means for companies to frame issues in ways that serve their own interests, shift responsibility from producers to consumers, emphasise voluntary regulations, and establish corporate legitimacy. Although these studies do not directly measure environmental greenwashing, they indicate that environmental sustainability claims should not be assessed independently of the alcohol industry's broader corporate reputation strategies.[105]

103 Laura Bathie et al., "The Prevalence of Environmental Claims and Recycling Information on Alcohol Products," *Sustainability* 18, no. 2 (2026): 800, accessed: 27 August 2026, https://www.mdpi.com/2071-1050/18/2/800.

104 Bathie et al., "The Prevalence of Environmental Claims," Fig. 1.

105 Sungwon Yoon and Tai-Hing Lam, "The Illusion of Righteousness: Corporate Social Responsibility Practices of the Alcohol Industry," *BMC Public Health* 13 (2013): 630, accessed 27 August 2026, https://doi.org/10.1186/1471-2458-13-630



CHAPTER 3: ADDICTION PREVENTION AND ITS IMPACT ON PLANETARY HEALTH

In addition to their effects on individual and public health, addictions must also be considered in terms of environmental sustainability and planetary health. As discussed in previous chapters, addictive substances and behaviours are associated with various environmental impacts, including natural resource consumption, energy use, greenhouse gas emissions, and waste generation. These impacts indicate that efforts to address addictions can be considered not only in terms of individual and public health but also within the context of environmental sustainability.

In this context, addiction prevention can be regarded as a public health approach that may contribute to limiting environmental impacts, beyond reducing health-related risks. Moreover, the effects of climate change on individual and community life are also relevant to addiction risks. Therefore, the relationship between addiction prevention and planetary health needs to be examined in terms of both the potential environmental co-benefits of prevention efforts and the risks arising from climate change.

3.1. The Contribution of Addiction Prevention to Climate and Planetary Health

The environmental impacts of addictions extend from the production of addictive products and services to the waste generated after consumption. These impacts occur across various areas, including agricultural production, water and energy use, raw material requirements, packaging, transportation, digital infrastructure, and waste management. In the case of tobacco products, agricultural land and water use and waste generation are particularly significant. For alcoholic beverages, agricultural production and packaging are prominent, while the effects of illicit drug production on ecosystems and the energy and resource demands of devices, networks, and data centre infrastructure are key concerns in relation to digital addictions.[1] These environmental impacts are examined in detail in the relevant sections of this report.

The environmental significance of addiction prevention stems from its potential to intervene at earlier stages in the processes that generate these impacts. Addiction prevention encompasses preventing or delaying the initiation of use, reducing risk factors while strengthening protective factors, and preventing risky patterns of use from progressing to more severe levels. This is a preventive public health approach that aims to reduce the likelihood of health and social problems that may arise after addiction develops.[2]

In this context, addiction prevention may also make an important contribution to environmental sustainability. The potential benefits of prevention efforts for climate and environmental health can be considered under three main headings: limiting the environmental impacts of addictive products and services by reducing long-term demand for them, reducing the need for addiction-related healthcare services, and strengthening individual and community resilience in the face of emerging risks associated with climate change. It should be noted, however, that many of these potential environmental co-benefits are inferred from the combined findings of scientific research across different disciplines rather than from studies directly examining the environmental effects of addiction prevention interventions.

The first contribution that addiction prevention can make to environmental sustainability is reducing long-term demand for addictive products and services. Prevention efforts can help reduce the environmental impacts generated throughout the life cycle of these products and services by preventing or delaying the initiation of use and preventing risky patterns of use from developing into prolonged and intensive consumption. These effects can arise at various stages, from agricultural production and raw material requirements to water and energy use, manufacturing, transportation, packaging, and post-consumption waste. For example, a study covering

1 World Health Organization, *Tobacco: Poisoning Our Planet* (World Health Organization, 2022), accessed: 12 October 2026, https://www.who.int/publications/i/item/9789240051287; United Nations Office on Drugs and Crime, *Contemporary Issues on Drugs*, *World Drug Report 2025*, Booklet 2 (United Nations, 2025), accessed: 12 October 2026, https://www.unodc.org/unodc/en/data-and-analysis/wdr2025-contemporary-issues.html; International Energy Agency, *Energy and AI* (IEA, 2025), accessed: 12 October 2026, https://www.iea.org/reports/energy-and-ai.

2 United Nations Office on Drugs and Crime and World Health Organization, *International Standards on Drug Use Prevention*, 2nd updated edition (United Nations Office on Drugs and Crime and World Health Organization, 2018), accessed: 12 October 2026, https://www.who.int/publications/i/item/international-standards-for-drug-use-prevention-second-edition-2018.

164 countries and territories examined the environmental impacts of tobacco consumption across global supply chains and found that scenarios involving reduced tobacco use prevalence could lead to lower greenhouse gas emissions, water consumption, and agricultural land use. Under different tobacco control scenarios, the study estimated potential reductions of 12–31% in global agricultural land use and 1.5–22% in non-agricultural water consumption by 2027, compared with 2020 levels.[3] Another study examining the life cycle of tobacco products estimated that a single cigarette has a water footprint of approximately 3.7 litres and consumes the equivalent of 3.5 grams of fossil fuels, measured in oil equivalents.[4] These findings demonstrate that reducing tobacco consumption is also important in terms of natural resource use and greenhouse gas emissions. Therefore, addiction prevention can be regarded as a public health intervention that may help reduce the environmental pressures associated with the life cycles of addictive products and services by limiting demand over the long term.

The second environmental contribution of addiction prevention may arise from reducing the need for healthcare services associated with addiction and related health conditions. Addiction-related health problems place a substantial burden on emergency departments, inpatient and outpatient care, diagnostic services, and medication use. For example, smoking cessation has been highlighted not only as a means of preventing tobacco-related diseases but also as a potential way to reduce the carbon footprint associated with tobacco production and the healthcare services required to treat these diseases.[5] Studies have shown that emergency department patients with substance use disorders are more likely to revisit emergency services and require hospitalisation.[6] Similarly, tobacco and alcohol use increase the risk of cardiovascular diseases, cancer, and other chronic conditions, thereby increasing the demand for healthcare services. Community-level tobacco control policies, including smoke-free legislation, have also been associated with reductions in cardiovascular and respiratory diseases and related hospital admissions.[7]

This potential reduction in healthcare demand becomes particularly important when the environmental impacts of healthcare systems are taken into account. Healthcare is estimated to account for approximately 4–5% of global greenhouse gas emissions.[8] Pharmaceuticals, medical equipment, single-use supplies, transportation, food, water, waste management, and healthcare supply chains are all relevant contributors to this environmental footprint.[9] Therefore, preventing addiction and related diseases may help reduce environmental harm by lowering future demand for healthcare services. From this perspective, addiction prevention and efforts to reduce the environmental impact of healthcare services can be considered complementary components of a sustainable healthcare system. The World Health Organization also identifies disease prevention as a key component of environmentally sustainable healthcare systems.[10]

The third link between addiction prevention and climate change concerns strengthening individual and community resilience to emerging climate-related risks. This relationship also involves reciprocal interactions. Climate change and extreme weather events may increase addiction risks through disasters, displacement, economic losses, weakened social support networks, mental health problems, and disruptions in access to services (see Section 1.4). Climate change has been identified as a potential contributor to increased addiction

3 Bolin Yu et al., "Assessing Sustainability Effects of Tobacco Use and Control in Global Supply Chains," *Nature Communications* 17 (2026): 1010, published online 17 December 2025, https://doi.org/10.1038/s41467-025-67755-9.

4 Maria Zafeiridou, Nicholas S. Hopkinson, and Nikolaos Voulvoulis, "Cigarette Smoking: An Assessment of Tobacco's Global Environmental Footprint Across Its Entire Supply Chain," *Environmental Science h Technology* 52, no. 15 (2018): 8087–8094, https://doi.org/10.1021/acs.est.8b01533.

5 Samantha Green and Meghan Davis, "Environmental Effect of Smoking Cessation," *Canadian Family Physician* 67, no. 12 (2021): 882–883, https://doi.org/10.46747/cfp.6712882_1.

6 Xingyu Zhang et al., "Emergency Department Visits by Patients with Substance Use Disorder in the United States," *Western Journal of Emergency Medicine* 22, no. 5 (2021): 1076–1085, https://doi.org/10.5811/westjem.2021.3.50839.

7 Shamima Akter et al., "Evaluation of Population-Level Tobacco Control Interventions and Health Outcomes: A Systematic Review and Meta-Analysis," *JAMA Network Open* 6, no. 7 (2023): e2322341, https://doi.org/10.1001/jamanetworkopen.2023.22341.

8 Mattis Keil et al., "Carbon Footprint of Healthcare Systems: A Systematic Review of Evidence and Methods," *BMJ Open* 14, no. 4 (2024): e078464, https://doi.org/10.1136/bmjopen-2023-078464; Lucas Rodríguez-Jiménez et al., "The Carbon Footprint of Healthcare Settings: A Systematic Review," *Journal of Advanced Nursing* 79, no. 8 (2023): 2830–2844, https://doi.org/10.1111/jan.15671.

9 Manfred Lenzen et al., "The Environmental Footprint of Health Care: A Global Assessment," *The Lancet Planetary Health* 4, no. 7 (2020): e271–e279, https://doi.org/10.1016/S2542-5196(20)30121-2; Rodríguez-Jiménez et al., "The Carbon Footprint of Healthcare Settings."

10 World Health Organization Regional Office for Europe, *Environmentally Sustainable Health Systems: A Strategic Document* (WHO Regional Office for Europe, 2017), accessed: 12 October 2026, https://www.who.int/publications/i/item/WHO-EURO-2017-2241-41996-57723.



risk through psychosocial stress, mental disorders, physical health burdens, adverse changes in established behavioural patterns, and climate-related anxiety.[11] Climate events may also be associated with increases in substance use and may lead to unplanned withdrawal, changes in drug markets, and disruptions in access to services.[12]

This relationship should also be examined in the context of social and environmental inequalities. The effects of climate change can vary depending on individuals' living environments, socioeconomic circumstances, social support networks, and access to healthcare services. Therefore, addiction prevention should also focus on individuals' social and physical environments and their vulnerability to climate change. Strengthening protective factors and developing support mechanisms, particularly for individuals and groups that are highly vulnerable to climate change, may help reduce future addiction risks. From this perspective, prevention can be understood not only as an approach that may contribute to reducing environmental harm but also as a public health strategy that supports community resilience to the potential effects of climate change on addiction risks.[13]

Prevention efforts targeting children and young people are particularly important in this context. Developing decision-making, self-regulation, critical thinking, peer pressure management, stress management, and healthy living skills may help reduce addiction risks.[14] These same skills also have the potential to support children and young people in developing resilience in response to changing environmental and social conditions. Accordingly, prevention efforts undertaken during childhood and adolescence should be considered not only in terms of reducing addiction risks but also in terms of strengthening individuals' capacity to cope with environmental and social challenges they may encounter in the future.

11 Francis Vergunst, Helen L. Berry, Kelton Minor, and Nicholas Chadi, "Climate Change and Substance-Use Behaviors: A Risk-Pathways Framework," *Perspectives on Psychological Science* 18, no. 4 (2023): 936–954, https://doi.org/10.1177/17456916221132739.

12 Sarah MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs? A Scoping Review of Peer Reviewed Literature," *International Journal of Drug Policy* 134 (2024): 104649, https://doi.org/10.1016/j.drugpo.2024.104649.

13 Vergunst et al., "Climate Change and Substance-Use Behaviors"; MacLean et al., "How Does Climate Change Impact People Who Use Alcohol and Other Drugs?"

14 United Nations Office on Drugs and Crime and World Health Organization, *International Standards on Drug Use Prevention*.

In conclusion, addiction prevention can play a protective role in environmental and climate health by reducing long-term demand for addictive substances and services, limiting the need for addiction-related healthcare services, and strengthening individual and community resilience to emerging risks associated with climate change. Nevertheless, further research directly examining the environmental outcomes of prevention programmes is needed to determine the magnitude of these potential benefits and the conditions under which they may arise.

Numerous programmes and policies are implemented worldwide and in Türkiye to prevent the onset of addiction, delay the initiation of substance use, and prevent risky patterns of use from progressing to addiction. These initiatives cover a broad range of activities, from school- and family-based education and life skills development to early intervention and community-level regulatory policies. An examination of internationally implemented prevention programmes reveals that school-based initiatives aimed particularly at developing the social and emotional skills of children and young people are prominent. Some programmes implemented in the United States and Europe provide examples of interventions designed to prevent tobacco, alcohol, and other substance use by strengthening decision-making, stress management, self-control, and resistance to peer pressure. In addition to educational programmes, regulatory policies such as taxation of addictive products and advertising restrictions constitute important components of prevention at the population level.

In Türkiye, the Green Crescent is one of the principal organisations delivering this comprehensive prevention approach to broad target populations. The Green Crescent's efforts to combat addiction encompass primary prevention, which seeks to address risk factors before they emerge, reduce risks before addiction develops, and strengthen healthy behaviours, as well as secondary prevention, which aims to prevent progression when early signs appear. These activities form a multilayered structure in which education, life skills development, early intervention, awareness-raising, and advocacy complement one another across schools, families, neighbourhoods, and communities.

The environmental significance of these initiatives can also be assessed in terms of their early intervention in the processes that contribute to the onset and progression of addiction. As discussed in Section 3.1, the environmental impacts of addiction extend from raw material extraction and agricultural production to energy and water consumption, manufacturing and distribution, packaging and post-consumption waste, digital infrastructure, and the use of resources by healthcare systems to address addiction-related diseases. Accordingly, interventions that prevent or delay the onset of addiction or prevent risky patterns of use from progressing to more severe levels may also help prevent some of these environmental harms. However, because the sources reviewed in this text do not include any study that directly measures the environmental impact of the Green Crescent's prevention programs, the benefits discussed below should be regarded as potential environmental effects that can be scientifically investigated, rather than as measured environmental outcomes.

One of the Green Crescent's largest-scale prevention initiatives, the Green Crescent Addiction Prevention Training Programme (TBM), provides an important example in this regard. TBM consists of six modules covering tobacco, alcohol, substance use, gambling, technology addiction, and healthy living. It is implemented through content developed for different age groups, ranging from preschool children to adults. The programme has an extensive network of practitioners across Türkiye and reaches millions of students and adults each year.[15] The potential environmental impact of primary prevention activities implemented on this scale lies in preventing or delaying future demand for addictive products and services. In particular, when the use of tobacco, alcohol, and other psychoactive substances is prevented or initiated later in life, the associated production, packaging, transportation, and waste generation that might otherwise accumulate over many years may be avoided or reduced. The magnitude of this effect has not yet been calculated specifically for TBM. Nevertheless, given the programme's broad target population, incorporating the potential environmental co-benefits of prevented or delayed substance use into future programme evaluations represents an important area for research. This issue can also be considered in terms of strengthening children's and young people's capacity for healthy coping and resilience in the face of climate change, disasters, social changes, and other stressors.

15 Türkiye Yeşilay Cemiyeti, "Türkiye Bağımlılıkla Mücadele Eğitim Programı," *Yeşilay*, erişim tarihi: 12 Ekim 2026, https://www.yesilay.org.tr/bagisyap/projeler-bagis/onleme-projeleri/turkiye-bagimlilikla-mucadele-egitim-programi/.

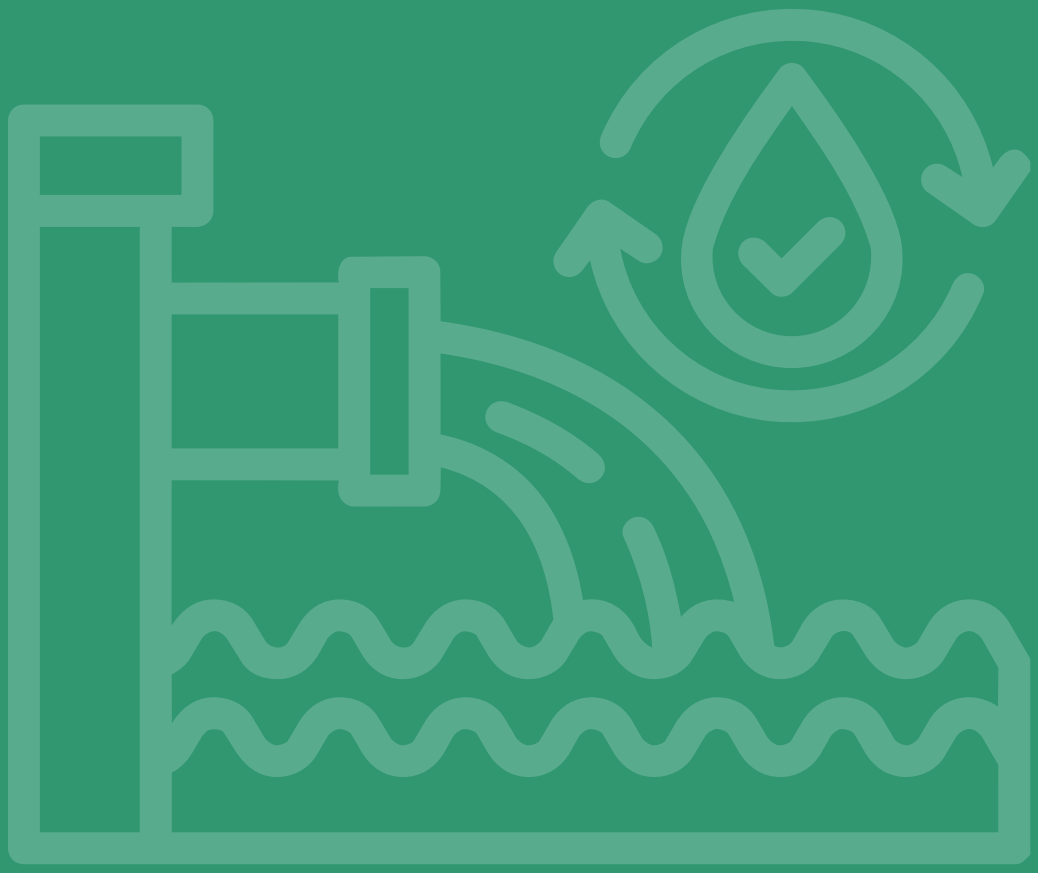
The Green Crescent Life Skills Training Programme (YYBE) represents another dimension of addiction prevention. Developed for middle school students, the programme aims to strengthen protective factors by promoting life skills such as stress management, self-management, effective communication, and empathy.[16] Developing protective skills that help prevent the onset or progression of addiction is one of the prevention mechanisms that may influence long-term demand for addictive products and services, as well as the health burden associated with addiction.

The Green Crescent's School-Based Addiction Intervention Programme (OBM) goes beyond primary prevention by focusing on middle and high school students who have begun experimenting with substances or engaging in risky patterns of use but have not yet developed an addiction.[17] From an environmental perspective, the significance of OBM lies in its potential to intervene before substance use progresses to addiction. However, it should be emphasised that the environmental benefits of this programme have not been directly measured.

When the Green Crescent's protective and preventive services are considered within this framework, three main pathways through which environmental co-benefits may arise can be identified. First, school- and community-based initiatives may help prevent the emergence or growth of future demand for addictive products and services. Second, reducing risk factors, preventing substance use from progressing to addiction, and limiting the associated need for healthcare services may help reduce environmental pressures. Third, these initiatives may contribute to creating more protective social environments for children and young people. Taken together, these three pathways suggest that addiction prevention initiatives constitute a multilevel public health intervention that can contribute to the development of healthier environments and more resilient communities. At a time when the health impacts of climate change are becoming increasingly apparent, strengthening this preventive capacity is particularly important for reducing future health risks.

16 Türkiye Yeşilay Cemiyeti, "Yeşilay Yaşam Becerileri Eğitim Programı," *Yeşilay*, erişim tarihi: 12 Ekim 2026, https://www.yesilay.org.tr/yybe/.

17 Türkiye Yeşilay Cemiyeti, "Okulda Bağımlılığa Müdahale Programı," *Yeşilay*, erişim tarihi: 12 Ekim 2026, https://www.yesilay.org.tr/obm/.



CHAPTER 4:
MONITORING ENVIRONMENTAL AND PUBLIC HEALTH: WASTEWATER-BASED EPIDEMIOLOGY

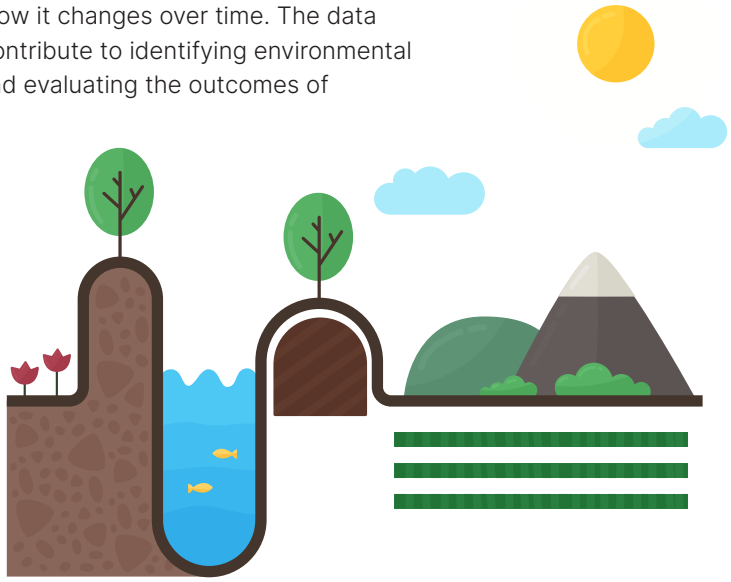
Considering environmental and public health together provides a common framework for monitoring psychoactive substance use and the residues these substances leave in the environment. Drawing on environmental monitoring practices, this section examines the information that wastewater analysis can provide about public health and substance use. Following examples of implementation from Türkiye and around the world, the environmental impacts of psychoactive substances are discussed, and research conducted by the Green Crescent to assess the presence of these substances in wastewater and their potential environmental risks is presented.

The Green Crescent's research on monitoring psychoactive substances in wastewater is important for evaluating population-level indicators of substance use alongside environmental monitoring data. The findings may help establish the presence of the substances analysed in wastewater and identify temporal or spatial variations in their concentrations. However, when assessing the study from an environmental health perspective, estimates of substance consumption must be distinguished from the potential effects of residues that may remain in the environment after wastewater treatment. Within this framework, the research findings should be considered collectively in relation to environmental monitoring, wastewater management, and measures to protect public health.

4.1. Environmental Monitoring Activities

In wastewater-based epidemiology (WBE), two distinct areas of assessment must be differentiated. The first involves estimating population-level consumption patterns based on substances and their metabolites excreted by the human body. The second examines how these substances behave in the environment after entering sewerage systems and wastewater treatment plants, as well as the risks they may pose to aquatic organisms. Although these two areas can be linked through data obtained from the same samples, they address different research questions and require different assessment criteria. Indicators used to estimate population-level consumption do not directly establish the magnitude of ecological risk. Ecological risk assessment requires the joint examination of environmental concentrations, the persistence of substances in the environment, their effects on organisms, and the conditions of exposure.[1]

Protecting human health from a planetary health perspective requires monitoring changes in environmental systems and assessing their effects on health in an integrated manner.[2] Environmental monitoring involves the systematic collection and assessment of data on the state of the environment and how it changes over time. The data obtained through environmental monitoring contribute to identifying environmental problems, tracking environmental changes, and evaluating the outcomes of implemented policies.[3]



Environmental monitoring activities address a range of issues, including air and water quality, soil characteristics, land use, biodiversity, waste generation, and waste management. Data obtained through monitoring networks, field studies, and remote sensing enable environmental conditions to be compared across different locations and time periods.[4] For example, satellite imagery can be

1 Lin Ding and Chong-Miao Zhang, "Occurrence, Ecotoxicity and Ecological Risks of Psychoactive Substances in Surface Waters," *Science of the Total Environment* 926 (2024): 171788, https://doi.org/10.1016/j.scitotenv.2024.171788; Taja Verovšek et al., "Removal of Residues of Psychoactive Substances during Wastewater Treatment, Their Occurrence in Receiving River Waters and Environmental Risk Assessment," *Science of the Total Environment* 866 (2023): 161257, https://doi.org/10.1016/j.scitotenv.2022.161257.

2 Montira J. Pongsiri et al., "Planetary Health: From Concept to Decisive Action," *The Lancet Planetary Health* 3, no. 10 (2019): e402–4, https://doi.org/10.1016/S2542-5196(19)30190-1.

3 United Nations Economic Commission for Europe, *Guidelines for the Application of Environmental Indicators: 2023 Edition* (United Nations, 2024), https://unece.org/environment-policy/publications/guidelines-application-environmental-indicators-2023-edition.

4 *United Nations Economic Commission for Europe, Guidelines for the Application of Environmental Indicators.*

used to monitor changes in land cover and air pollution, while citizen science initiatives can generate information about biodiversity and habitats.[5]

From a planetary health perspective, evaluating environmental data alongside health and socioeconomic data is important for understanding where risks are concentrated geographically and across different population groups.[6] Making environmental monitoring data meaningful for public health requires not only measuring environmental changes but also examining how these changes relate to human health and living conditions. Therefore, environmental data should be assessed alongside epidemiological indicators, population characteristics, and information on healthcare services. For example, changes in water quality, the presence of specific chemical substances in the environment, or variations observed in wastewater may contribute to the planning of preventive measures when examined alongside relevant health data. However, identifying an environmental indicator does not, in itself, demonstrate that a health effect has occurred. Causal relationships and the level of risk must be assessed separately. This integrated approach establishes a link between identifying environmental hazards and making decisions to protect public health.[7] The World Health Organization's report on climate change and health indicators examines hazards such as heatwaves and floods alongside the populations exposed to them, characteristics that influence vulnerability, including age and income, and resulting health outcomes. Within this framework, the importance of incorporating climate data into existing monitoring and early warning systems is emphasised to support the early identification of health risks and the planning of appropriate preventive measures.[8]

For the information obtained through monitoring to contribute effectively to preventive action, data must be collected regularly and in a comparable manner, shared across institutions, and incorporated into decision-making processes.[9] In Türkiye, air, water, and wastewater monitoring activities also provide information to support the identification of environmental risks and efforts to prevent pollution.

4.1.1. Environmental Monitoring Activities and Areas for Development in Türkiye

In Türkiye, environmental monitoring activities cover air quality, water resources, and wastewater through different monitoring systems. Air pollutants are continuously measured through the National Air Quality Monitoring Network, and the resulting data are used to assess air quality and support regulatory inspections.[10] Under river basin management plans, the physical, chemical, and biological characteristics of water resources are assessed to identify measures for protecting and improving water quality.[11] Within the Continuous Wastewater Monitoring Systems (CWMS), wastewater quality is monitored, while automated measurement and sampling practices support inspection and enforcement processes.[12]

To further develop these activities, priority areas may include evaluating data produced by different institutions using common standards, strengthening inter-institutional data sharing, and regularly communicating findings to the public.[13] In addition, assessing environmental measurements alongside health and socioeconomic data may help identify the regions and population groups most affected by environmental risks and support the planning of preventive measures tailored to their needs.[14]

To enhance the contribution of environmental monitoring systems to public health in Türkiye, data generated by different institutions should be assessed within common evaluation frameworks. This process may draw on

5 Pongsiri et al., "Planetary Health."

6 Pongsiri et al., "Planetary Health."

7 Ding and Zhang, "Occurrence, Ecotoxicity and Ecological Risks."

8 World Health Organization, Mapping Climate Change and Health Indicators

9 United Nations Economic Commission for Europe, Guidelines for the Application of Environmental Indicators.

10 Ministry of Environment, Urbanization and Climate Change, "Real-Time Monitoring of Türkiye's Air Quality," 31 January 2025, https://lab.csb.gov.tr/haberler/turkiyenin-hava-kalitesine-anlik-takip-290365.

11 Ministry of Agriculture and Forestry, General Directorate of Water Management, "A Strategic Step for Türkiye's Water Future: Preparing River Basin Management Plans," 7 August 2026, https://www.tarimorman.gov.tr/SYGM/Haber/1393/Turkiyenin-Su-Gelecegi-Icin-Stratejik-Adim-Nehir-Havza-Yonetim-Planlarini-Hazirliyoruz.

12 Ministry of Environment, Urbanization and Climate Change, "Continuous Wastewater Monitoring Studies," accessed: 8 October 2026, https://lab.csb.gov.tr/surekli-atiksu-izleme-calismalari-i-5902.

13 United Nations Economic Commission for Europe, Guidelines for the Application of Environmental Indicators.

14 Pongsiri et al., "Planetary Health."

aggregated data presented at appropriate spatial scales while ensuring the confidentiality of personal health information. Jointly assessing environmental risks, population characteristics, health indicators, and access to services at the provincial and district levels can provide a clearer understanding of whether risks are concentrated in particular areas. Such analyses can support the development of local health profiles, the identification of priority areas for intervention, and evidence-based planning by municipalities and healthcare institutions. However, differences in the spatial scales at which data are generated, variations in data coverage and quality, and requirements for personal data protection must all be taken into account. The analysis of wastewater not only enables the monitoring of pollution but also provides information relating to public health. Wastewater-based epidemiology, which utilises chemical and biological markers in wastewater, is used to monitor infectious diseases and various forms of exposure, as well as the consumption of psychoactive substances at a population level.[15]

4.2. Wastewater-Based Epidemiology in Public Health Monitoring

Wastewater-based epidemiology is an approach that provides information about population health, substance use, and exposure to environmental chemicals through the analysis of chemical and biological traces found in wastewater.[16] Based primarily on the analysis of samples collected from influent wastewater, this approach enables population-level changes to be monitored in near real time.[17] Wastewater analyses examine substances excreted by the human body, the products formed through their metabolism, and the genetic material of disease-causing agents.[18] While wastewater-based epidemiology refers to the scientific field in which these findings are linked to population health, wastewater surveillance refers to the continuous and systematic monitoring of health-related indicators through wastewater.[19]



One of the main applications of this approach is the monitoring of infectious diseases. The detection of pathogens such as poliovirus and SARS-CoV-2 in wastewater contributes to assessing their circulation within the population and changes in their prevalence over time.[20] In particular, practices that became more widespread during the COVID-19 pandemic demonstrated that wastewater data can provide early warnings of increases in infections before these increases are detected through clinical surveillance.[21] In addition, the analysis of antibiotics, antibiotic-resistant bacteria, and resistance genes in wastewater forms part of efforts to monitor antimicrobial resistance.[22]

The analysis of chemical substances in wastewater is used to assess pharmaceutical and psychoactive substance consumption, as well as to investigate exposure to environmental chemicals such as pesticides. Measured concentrations are evaluated alongside wastewater flow rates to calculate daily substance loads. By taking into account the population served by the wastewater treatment plant from which samples are collected, comparisons can be made across different regions and time periods. However, the presence of a chemical in wastewater does not, in itself, demonstrate that people

15 Devin A. Bowes, Erin. M. Driver, Phil M. Choi, Damia Barcelo, and Paloma I. Beamer, "Wastewater-based epidemiology to assess environmentally influenced disease," *Journal of Exposure Science h Environmental Epidemiology,* 34, no. 3, (2024): 387-388. https://doi.org/10.1038/s41370-024-00683-w.

16 Barbara Kasprzyk-Hordern et al., "Wastewater-Based Epidemiology for the Assessment of Population Exposure to Chemicals: The Need for Integration with Human Biomonitoring for Global One Health Actions," *Journal of Hazardous Materials* 450 (2023): 131009, https://doi.org/10.1016/j.jhazmat.2023.131009.

17 Bowes et al., "Wastewater-Based Epidemiology."

18 Kasprzyk-Hordern et al., "Wastewater-Based Epidemiology for the Assessment of Population Exposure to Chemicals."

19 David A. Larsen et al., "Wastewater Monitoring, Surveillance and Epidemiology: A Review of Terminology for a Common Understanding," *FEMS Microbes* 2 (2021): xtab011, https://doi.org/10.1093/femsmc/xtab011.

20 Larsen et al., "Wastewater Monitoring, Surveillance and Epidemiology."

21 Bowes et al., "Wastewater-Based Epidemiology."

22 Kasprzyk-Hordern et al., "Wastewater-Based Epidemiology for the Assessment of Population Exposure to Chemicals."

have been exposed to that substance. It is therefore important to select substances known to be excreted by the human body or their metabolic products (metabolites) for analysis.[23] The analysis of psychoactive substances and their metabolites using this method forms the basis for monitoring changes in substance consumption at the population level.[24]

Wastewater-based epidemiology offers several advantages, including the fact that it does not require biological samples to be collected from individuals separately and enables the population served by a wastewater treatment plant to be assessed collectively. The ability to obtain information from individuals who do not seek healthcare can broaden the coverage of existing monitoring systems.[25] However, when interpreting the results, uncertainties in population estimates, daily variations in wastewater flow, industrial inputs, and the degradation of the substances analysed within sewerage systems must also be taken into account.[26] It is therefore important to assess wastewater findings alongside clinical and other epidemiological data. In monitoring psychoactive substance use, these data can contribute to identifying changes in consumption patterns and informing the planning of prevention initiatives.[27]

4.2.1. Wastewater-Based Epidemiology in the Monitoring of Psychoactive Substances

Wastewater-based epidemiology enables the monitoring of psychoactive substance consumption among populations living in specific areas, the identification of consumption patterns, and comparisons between regions. In addition to cocaine, amphetamine, methamphetamine, MDMA, and cannabis, alcohol and nicotine consumption can also be monitored through the analysis of the substances themselves or their metabolites. These analyses enable estimates of the total quantities of substances consumed by the population served by a wastewater treatment plant during a specific period. Evaluating these estimates alongside surveys, treatment admissions, and other indicators can support the planning of prevention initiatives.[28] Furthermore, detecting new psychoactive substances in wastewater can contribute to monitoring their use and supporting early warning systems.[29]

One of the main international initiatives monitoring psychoactive substances in wastewater is conducted by the European Union Drugs Agency (EUDA) and the Sewage Analysis CORe Group Europe (SCORE). Standardised sampling and laboratory analysis protocols are applied to ensure that results are comparable across cities and years. The 2025 implementation of the study covered a total of 115 cities across European Union countries, Norway, and Türkiye. Among cities with data available for both years, the concentration of the cocaine metabolite increased by 22% and ketamine concentrations rose by approximately 41% from 2024 to 2025, while MDMA concentrations decreased by approximately 16%.[30]

Monitoring programmes conducted in different countries demonstrate how wastewater data can be used to track changes in substance consumption and support decision-making. In Australia, the findings of the national monitoring programme are reported regularly to enable relevant institutions to monitor changes in consumption and develop policies in response to identified needs.[31] In New Zealand, a programme covering approximately 80% of the population enables changes to be monitored by comparing regional consumption estimates with

23 Kasprzyk-Hordern et al., "Wastewater-Based Epidemiology for the Assessment of Population Exposure to Chemicals."

24 Bowes et al., "Wastewater-Based Epidemiology."

25 Larsen et al., "Wastewater Monitoring, Surveillance and Epidemiology."

26 Kasprzyk-Hordern et al., "Wastewater-Based Epidemiology for the Assessment of Population Exposure to Chemicals."

27 Bowes et al., "Wastewater-Based Epidemiology."

28 European Monitoring Centre for Drugs and Drug Addiction, *Assessing Illicit Drugs in Wastewater: Advances in Wastewater-Based Drug Epidemiology*, Insights 22 (Publications Office of the European Union, 2016), https://doi.org/10.2810/017397.

29 European Union Drugs Agency, "Wastewater Analysis and Drugs—A European Multi-City Study," updated March 18, 2026, https://www.euda.europa.eu/publications/pods/waste-water-analysis_en.

30 European Union Drugs Agency, "Wastewater Analysis and Drugs."

31 Australian Criminal Intelligence Commission, "National Wastewater Drug Monitoring Program Reports," accessed October 8, 2026, https://www.acic.gov.au/publications/national-wastewater-drug-monitoring-program-reports.

those from previous periods.[32] In Finland, wastewater findings are combined with data from other studies and records to provide a more comprehensive assessment of substance use.[33]

Within the scope of Türkiye's 2024–2028 Action Plan for Combating Drug Addiction, the Project for Monitoring Psychoactive Substances in Wastewater is being implemented in cooperation with the Turkish Green Crescent Society and the Department of Anti-Smuggling Intelligence, Operations and Information Collection (KİHBİ) of the Ministry of Interior. Launched in 18 provinces in 2019, the project involves the periodic collection of samples from 136 wastewater treatment plants across 71 provinces, in which heroin, amphetamine, methamphetamine, MDMA, cocaine, cannabis, alcohol, and nicotine, as well as new psychoactive substances, are analysed.

Wastewater studies conducted in Türkiye also include research comparing consumption estimates with existing records. In this context, a study conducted in 31 cities examined pregabalin, a prescription medication, and compared consumption levels calculated from wastewater analyses with pharmacy sales data. In some cities, pregabalin consumption estimated through wastewater analyses was found to exceed the levels expected based on pharmacy sales. This discrepancy indicated the need for a more detailed investigation into the possibility of non-prescription access to the medication or its use for purposes other than medical treatment.[34] In another study conducted in Türkiye, a method was developed to enable the simultaneous analysis of 30 new psychoactive substances and six illicit substances. When the method was applied to 63 wastewater samples, synthetic cannabinoids that mimic the effects of cannabis and mephedrone, a substance with stimulant effects, were detected. This study demonstrates that wastewater analysis can be used to detect numerous new psychoactive substances in addition to those routinely monitored.[35]

The expansion of wastewater monitoring systems that provide information at the population level also brings responsibilities regarding the ethical use of data. Although wastewater analyses do not involve the collection of individual biological samples, risks such as breaches of privacy, stigmatization, and the use of data for purposes other than those intended may arise when detailed findings are generated about small settlements or specific communities.[36] Therefore, it is important for monitoring programmes to clearly define the purpose of data collection, determine the geographical and population scales at which results will be shared in a manner that safeguards privacy, establish conditions for data access and storage, and assess potential harms in advance.[37] In particular, when communicating findings on substance use to the public, expressions that could stigmatize or blame specific regions or communities should be avoided.[38] Information obtained through wastewater surveillance should be used to protect public health and improve services in line with identified needs.[39]

The fate of psychoactive substances investigated for the purpose of monitoring consumption after they enter wastewater is also important from an environmental health perspective. Despite treatment processes, psychoactive substances and their metabolites that remain in effluent water may reach the rivers, lakes, and seas into which effluent wastewater is discharged. A study examining six treatment plants in Slovenia and the rivers receiving their effluent waters found that some psychoactive substances were largely removed during treatment, whereas others remained in the treated water and reached the rivers.[40] Research on aquatic organisms has reported that certain psychoactive substances are associated with behavioural changes, organ damage, and cellular effects under specific exposure conditions.[41]

Nevertheless, the detection of a substance in water does not, in itself, demonstrate that ecological harm has occurred. To assess the risks posed by psychoactive substances to aquatic ecosystems, their concentrations

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32 New Zealand Police, "National Drugs in Wastewater Programme - Quarter 1, 2026," June 2026, https://www.police.govt.nz/about-us/publication/national-drugs-wastewater-programme-quarter-1-2026.

33 Finnish Institute for Health and Welfare, "Drugs—Population-Level Use by Region," updated September 3, 2026, https://thl.fi/en/data-and-statistics/drugs/population-level-use-by-region.

34 Ismail Ethem Goren et al., "Wastewater-Based Evidence of Pregabalin Misuse in Türkiye: Implications for Drug Policy and Surveillance," *International Journal of Drug Policy* 151 (2026): 105247, https://doi.org/10.1016/j.drugpo.2026.105247.

35 Merve Kuloglu Genc et al., "Uncovering the Hidden: Method Validation for Analysis of 36 Psychoactive Substances in Türkiye's Wastewater," *Journal of Chromatography A* 1760 (2025): 466304, https://doi.org/10.1016/j.chroma.2025.466304.

36 Dhiraj Nainani et al., "Balancing Public Health and Group Privacy: Ethics, Rights, and Obligations for Wastewater Surveillance Systems," *Water Research* 258 (2024): 121756, https://doi.org/10.1016/j.watres.2024.121756.

37 World Health Organization, *Ethics Framework for Wastewater and Environmental Surveillance* (World Health Organization, 2025), https://pandemichub.who.int/publications/i/item/9789240116412.

38 Jeremy Prichard et al., *Ethical Research Guidelines for Wastewater-Based Epidemiology and Related Fields*, version 1.0 (2016), https://www.euda.europa.eu/drugs-library/ethical-research-guidelines-wastewater-based-epidemiology-and-related-fields_en.

39 World Health Organization, Ethics Framework for Wastewater and Environmental Surveillance.

40 Verovšek et al., "Removal of Residues of Psychoactive Substances."

41 Ding and Zhang, "Occurrence, Ecotoxicity and Ecological Risks."

in water must be considered together with the levels at which they produce effects on living organisms.[42] Therefore, comparing the concentrations of psychoactive substances in the influent and effluent of treatment plants and assessing the potential environmental risks associated with substances remaining after treatment are important.

4.3. Green Crescent's Research on the Environmental Impact of Psychoactive Substances in Wastewater

4.3.1. Aim and Scope of the Research

The Research on the Environmental Impact of Psychoactive Substances in Wastewater is a study conducted under the leadership of the Turkish Green Crescent Society and designed to use wastewater-based epidemiology methods to jointly assess indicators of population-level consumption and environmental impacts. The primary aim of the research is to determine psychoactive substance concentrations at the influent and effluent points of selected wastewater treatment plants, establish the extent to which existing treatment processes remove these substances, and assess potential environmental risks to the receiving environments into which treated effluents are discharged.

Within the scope of the research, nine different psychoactive substances or metabolites were examined, including compounds classified as illicit substances and lifestyle substances. The substances investigated were morphine, amphetamine, methamphetamine, MDMA (3,4-methylenedioxymethamphetamine), benzoylecgonine (the primary urinary metabolite of cocaine), THC-COOH (the carboxylic acid metabolite of delta-9-tetrahydrocannabinol), cotinine (the primary metabolite of nicotine), ethyl sulfate (an early-phase metabolite of ethanol), and caffeine.

Seven wastewater treatment plants (WWTPs) were selected to ensure a comprehensive approach representing different geographical regions of Türkiye, population densities, levels of urban development, wastewater treatment technologies, and receiving water environments. Accordingly, high-capacity urban wastewater treatment plants in the provinces of Adana, Antalya, Hatay, İstanbul, İzmir, Samsun, and Trabzon were selected as research sites. These facilities were Adana Seyhan WWTP, Antalya Hurma WWTP, Hatay–İskenderun Biological Domestic WWTP, İstanbul Ambarlı Advanced Biological WWTP, İzmir Çiğli Advanced Biological WWTP, Samsun Doğu WWTP, and Trabzon Değirmendere WWTP. These facilities serve a combined population of more than 8.26 million and discharge their treated effluents into various receiving environments, including the Mediterranean Sea, the Aegean Sea, the Black Sea, the Sea of Marmara, and the Seyhan River.



Large urban wastewater treatment plants are important entry points through which psychoactive substances, classified as “urban-origin micropollutants,” reach the environment due to their high wastewater flow rates and the correspondingly high mass loads of pollutants. This sampling design enables regional-scale comparisons of the environmental distribution of psychoactive substances originating from urban wastewater across Türkiye and their behaviour during treatment processes. Significant differences exist among the selected facilities in terms of treatment technologies, with various systems represented, including biological treatment (UCT process), secondary biological treatment (activated sludge), advanced biological treatment

42 Hangbiao Jin et al., “Environmental Occurrence and Ecological Risks of Psychoactive Substances,” *Environment International* 158 (2022): 106970, https://doi.org/10.1016/j.envint.2021.106970.

(including the Bardenpho process), and physical pretreatment. In addition to determining the removal performance of wastewater treatment plants, the study assessed the potential for psychoactive substances detected in effluent wastewaters to reach receiving environments and the possible environmental risks these pollutants may pose to aquatic ecosystems, based on available data and environmental threshold values reported in the literature. Furthermore, the findings provide a scientific data foundation for urban wastewater management, water resource protection, strengthening the resilience of marine and coastal ecosystems, the circular economy, and the development of climate-resilient urban infrastructure.

4.3.2. Methodology and Sampling

4.3.2.1. Selection of Target Chemicals

The target chemicals selected for this research were determined based on the psychoactive substances and biomarkers prioritised for monitoring in wastewater in Türkiye, within the scope of the "Project for Monitoring Psychoactive Substances in Wastewater," conducted in cooperation between the Turkish Green Crescent Society and the Department of Anti-Smuggling Intelligence, Operations and Information Collection (KİHBİ) of the Ministry of Interior. The selection of these substances took into account parameters such as their consumption in Türkiye, the number of seizures, hospital and mortality records, as well as criteria supported by international literature and their suitability for analysis in wastewater. Additional selection criteria included the prevalence of substance use, biotransformation profiles in the human body, potential for environmental persistence, and frequency of reporting in previous wastewater monitoring studies.

The substances analysed in the study were benzoylecgonine, a metabolite of cocaine; THC-COOH, a metabolite of cannabis (THC); morphine, a metabolite of heroin; MDMA; methamphetamine; amphetamine; cotinine, a metabolite of nicotine (tobacco); EtS, a metabolite of alcohol; and caffeine. Due particularly to their low stability in wastewater, not every illicit substance and/or its metabolite can be analysed in wastewater. Specific parameters must be met for a substance to be considered suitable for use as a biomarker. All the analytes mentioned above met these parameters and were therefore quantified as biomarkers in the analyses.[43] Caffeine was included in the study not only as a pollutant but also as an indicator compound that can be used to assess human activities, domestic wastewater inputs, and the performance of wastewater treatment plants.[44]

4.3.2.2. Sample Collection

The wastewater treatment plants selected as research sites were Adana Seyhan WWTP (1,159,215 inhabitant), Antalya Hurma WWTP (1,400,000 inhabitant), Hatay–İskenderun Biological Domestic Wastewater Treatment Plant (439,000 inhabitant), İstanbul Ambarlı Advanced Biological WWTP (1,600,000 inhabitant), İzmir Çiğli Advanced Biological WWTP (2,885,209 inhabitant), Samsun Doğu WWTP (667,014 inhabitant), and Trabzon Değirmendere WWTP (115,015 inhabitant). Sample collection commenced on 15 September 2026 and continued for seven consecutive days (15–21 September 2026). At each facility, samples were collected from two points: the influent of the wastewater treatment plant (raw wastewater) and the effluent (treated wastewater). This approach enables the direct calculation of the effects of the treatment process on psychoactive substances and the removal efficiency.

43 F. Asicioglu et al., "Investigation of Temporal Illicit Drugs, Alcohol and Tobacco Trends in Istanbul City: Wastewater Analysis of 14 Treatment Plants," *Water Research, 190* (2021): 116729, https://doi.org/10.1016/j.watres.2020.116729; Nebile Daglioglu, Evsen Yavuz Guzel, and Serdar Kilercioglu, "Assessment of Illicit Drugs in Wastewater and Estimation of Drugs of Abuse in Adana Province, Turkey," *Forensic Science International, 294* (2019): 132–139, https://doi.org/10.1016/j.forsciint.2018.11.012; Nebile Daglioglu et al., "Estimating Alcohol Consumption by Using Wastewater-Based Epidemiology in Adana Province, Turkey," *Environmental Science and Pollution Research, 27* (2020): 31884–31891, https://doi.org/10.1007/s11356-020-09056-w; Nebile Daglioglu et al., "Comparison of Community Illicit Drug Use in 11 Cities of Turkey through Wastewater-Based Epidemiology," *Environmental Science and Pollution Research, 28* (2021): 15076–15089, https://doi.org/10.1007/s11356-020-11404-9; Evsen Yavuz Guzel et al., "Estimation of Alcohol and Nicotine Consumption in 11 Cities of Turkey Using Wastewater-Based Epidemiology," *Drug Testing and Analysis, 13*, no. 4 (2021): 853–861, https://doi.org/10.1002/dta.2979; Merve Kuloglu Genc et al., "Monitoring Geographical Differences in Illicit Drugs, Alcohol, and Tobacco Consumption via Wastewater-Based Epidemiology: Six Major Cities in Turkey," *Science of the Total Environment, 797* (2021): 149156, https://doi.org/10.1016/j.scitotenv.2021.149156; Selda Mercan et al., "Wastewater-Based Monitoring of Illicit Drug Consumption in Istanbul: Preliminary Results from Two Districts," *Science of the Total Environment, 656* (2019): 231–238, https://doi.org/10.1016/j.scitotenv.2018.11.345; Selda Mercan et al., "Comparison of Two Extraction Set-ups for the Determination of Illicit Drugs from Wastewater," *Turkiye Klinikleri Journal of Forensic Medicine and Forensic Sciences, 16*, no. 1 (2019): 28–36, https://doi.org/10.5336/forensic.2018-62466.

44 Attila Csaba Kondor et al., "Pharmaceuticals in Water and Sediment of Small Streams under the Pressure of Urbanization: Concentrations, Interactions, and Risks," *Science of the Total Environment, 808* (2022): 152160, https://doi.org/10.1016/j.scitotenv.2021.152160.

The selection of treatment plants in terms of their receiving environments was structured to identify different transport pathways for land-based pollutants. River systems such as the Seyhan River and Haramidere represent the transport of urban-origin pollutants through river networks, while sensitive coastal systems such as the Gulf of İskenderun and the Gulf of İzmir allow for the assessment of the potential accumulation and ecological effects of pollutants in coastal environments with more limited water exchange. Antalya Hurma WWTP represents open-sea/deep-sea discharges into the Mediterranean, while the Samsun and Trabzon facilities allow for comparisons of different urban and hydrological conditions along the Black Sea coast in the context of marine discharges.

Wastewater samples were collected at the influent and effluent points of the treatment plants using automatic composite sampling devices (autosamplers). The devices operated continuously for 24 hours, producing a daily composite sample with a total volume of 6 L. The resulting composite sample was mixed using three rotational movements to ensure homogenisation and was then transferred into 250 mL HDPE bottles. For each treatment plant, 7 days × 2 sampling points = 14 samples were submitted; a total of 98 samples from seven treatment plants were analysed.

To preserve analytical stability, the samples were stored at −20°C under cold-chain conditions and transported in foam (polystyrene) boxes with dry ice or ice packs to the laboratories of Ankara University Institute of Forensic Sciences and İstanbul University-Cerrahpaşa Institute of Forensic Medicine and Forensic Sciences. The samples were analysed within seven days of collection and were kept at −20°C until analysis.

4.3.2.3. Sample Preparation and Instrumental Analysis

In this study, the samples collected from Adana Seyhan WWTP, Hatay–İskenderun Biological Domestic WWTP, and Trabzon Değirmendere WWTP (n = 42) were analysed at the Ankara University Institute of Forensic Sciences Laboratory, while the samples collected from Antalya Hurma WWTP, İstanbul Ambarlı Advanced Biological WWTP, İzmir Çiğli Advanced Biological WWTP, and Samsun Doğu WWTP (n = 56) were analysed at the İstanbul University-Cerrahpaşa Institute of Forensic Medicine and Forensic Sciences Laboratory. Quantitative analysis of the target compounds was performed by two specialised laboratories using Liquid Chromatography–Tandem Mass Spectrometry (LC-MS/MS) in Multiple Reaction Monitoring (MRM) mode. At both laboratories, the samples were purified and concentrated using solid-phase extraction (SPE; Oasis HLB, 3 cc, 60 mg). The methods were validated in accordance with the guidelines of the Scientific Working Group for Forensic Toxicology (SWGTOX).

a) Istanbul University-Cerrahpaşa (IU-C), Institute of Forensic Medicine and Forensic Sciences

At the IU-C laboratory, analyses were performed using a Shimadzu 2040C UPLC (Ultra-High-Performance Liquid Chromatography) system and a Shimadzu LC-MS/MS 8045 triple-quadrupole mass spectrometer. Electrospray ionisation (ESI) was used as the ion source, with the ion transfer capillary temperature set to 250°C and the heat block temperature set to 450°C.

Chromatographic separation of the target compounds was performed using a Phenomenex Kinetex Biphenyl column (100 × 2.1 mm, 2.6 µm). The column temperature was set to 50°C, the injection volume to 2 µL, and the flow rate to 0.4 mL/min. The total analysis time was 17 minutes. The aqueous solution containing 2 mM ammonium formate and 0.1% formic acid was used as mobile phase A, while pure methanol was used as mobile phase B. A separate method was used for the analysis of cotinine and ethyl sulfate, with the flow rate reduced to 0.25 mL/min and the analysis time shortened to 9 minutes. In this method, mobile phase A consisted of an aqueous solution containing 0.1% formic acid, while methanol was used as mobile phase B.

The limits of quantification (LOQs) determined for all analytes were as follows: 1 ng/L for benzoylecgonine, 1 ng/L for MDMA, 1 ng/L for methamphetamine, 0.5 ng/L for amphetamine, 0.5 ng/L for THC-COOH, 1 ng/L for EtS, 1 ng/L for cotinine, 0.5 ng/L for morphine, and 1 ng/L for caffeine.

b) Ankara University (AU), Institute of Forensic Sciences

At the AU laboratory, analyses were performed using a Shimadzu LCMS-8050 triple-quadrupole LC-MS/MS system. Electrospray ionisation (ESI) was used as the ion source, with the capillary temperature set to 250°C and the heat block temperature set to 400°C.

Psychoactive substances, caffeine, and cotinine were analysed using a Restek Allure PFPP column (50 × 2.1 mm, 5 µm), while the alcohol metabolite ethyl sulfate was analysed using a Raptor Biphenyl column (100 × 2.1 mm,

2.7 µm). For the PFPP column, the temperature was set to 40°C, the flow rate to 0.4 mL/min, and the injection volume to 5 µL; the total analysis time was 18 minutes. For the ethyl sulfate method, the column temperature was set to 30°C, the flow rate to 0.3 mL/min, and the injection volume to 2 µL; the analysis time was 5.5 minutes. For the drug/cotinine method, an aqueous solution containing 10 mM ammonium formate was used as mobile phase A, while pure methanol was used as mobile phase B. For the ethyl sulfate method, an aqueous solution containing 0.1% formic acid was used as mobile phase A, while acetonitrile was used as mobile phase B. Gradient elution was performed using a binary gradient system in both methods.

The limits of quantification (LOQs) determined for all analytes were as follows: 0.1 ng/L for benzoylecgonine, 0.2 ng/L for MDMA, 0.5 ng/L for methamphetamine, 2.01 ng/L for amphetamine, 5 ng/L for THC-COOH, 1 ng/L for EtS, 0.5 ng/L for cotinine, 1.34 ng/L for morphine, and 1 ng/L for caffeine.

4.3.2.4. Removal Calculations

The removal efficiency of wastewater treatment plants for psychoactive substances was calculated using the following formula, based on concentration measurements in composite wastewater samples collected at the influent ($C_{influent}$) and effluent ($C_{effluent}$) points on the same day:

$$\textbf{Removal (\%)} = [(\textbf{Cinfluent} - \textbf{Ceffluent}) / \textbf{C}_{\textbf{influent}}] \times \textbf{100}$$

In the formula, $C_{influent}$ represents the concentration in raw wastewater collected at the influent point of the treatment plant (ng/L), while $C_{effluent}$ represents the concentration in treated water collected at the plant outlet (ng/L).[45] A positive removal percentage between 0 and 100 indicates that the treatment plant has partially or completely removed the substance in question. Negative removal values indicate that the effluent concentration is higher than the influent concentration, suggesting an increase in substance concentration due to biological transformation, bioaccumulation, or the hydrolysis of conjugated metabolites within the plant.[46] This phenomenon was observed to be particularly pronounced in facilities without a biological treatment unit, such as Trabzon Değirmendere WWTP, which was included in this study.

The measurements obtained over seven days were averaged for each plant to minimise the effects of daily variability. In the calculations, only daily pairs of measurements for which both influent and effluent concentrations were above the LOQ were used; when effluent values were below the LOQ, removal for that day was considered to be 100%. Removal efficiency was used as the primary criterion for inter-plant comparisons and for evaluating treatment effectiveness across different groups of psychoactive substances.

4.3.3. Key Findings

All the compounds investigated in the study were detected at measurable concentrations in the influent wastewater of at least one of the seven treatment plants. Differences in plant scale, treatment type, and population profile revealed distinct patterns in both concentration levels and removal efficiencies. The mean removal efficiency values for all plants and substances included in the study are presented in Table 1.

Morphine concentrations of influent wastewater ranged from 6.99 ng/L (Hatay–İskenderun WWTP) to 121.34 ng/L (İstanbul Ambarlı WWTP), and measurable concentrations were detected at all seven treatment plants. At the İstanbul Ambarlı (MBR + UV), Samsun Doğu, Antalya Hurma, and İzmir Çiğli WWTPs, effluent concentrations following advanced biological treatment were below the LOQ (0.50 ng/L), and removal was considered practically complete. Partial removal (81.62–91.76%) was observed at the Hatay–İskenderun (UCT process) and Adana Seyhan (activated sludge + sedimentation) plants. Trabzon Değirmendere WWTP, which lacks biological treatment, was able to remove only 3.94% of morphine through physical processes. Morphine is not an exclusive marker of heroin use, as it may also originate from the use of pharmaceutical products such as medicinal morphine and codeine. These findings confirm that morphine removal depends largely on biological treatment capacity. Morphine concentrations in influent wastewater at European wastewater treatment plants have been reported to range from 2.4 to 48 ng/L, with removal rates of 90–94% reported for biological treatment.[47] A

45 Yanghui Deng et al., "Occurrence and Removal of Illicit Drugs in Different Wastewater Treatment Plants with Different Treatment Techniques," *Environmental Sciences Europe, 32* (2020): 28, https://doi.org/10.1186/s12302-020-00304-x.

46 Anvar Asadi et al., "Illicit Drug Use Derived from Wastewater-Based Epidemiology in Iran, Their Removal during Wastewater Treatment, and Occurrence in Receiving Waters," *Heliyon, 11*, no. 3 (2025): e42516, https://doi.org/10.1016/j.heliyon.2025.e42516.

47 Verovšek et al., "Removal of Residues of Psychoactive Substances."

study conducted in South Australia demonstrated that morphine removal in a mixture of five pharmaceuticals improved substantially only when secondary treatment was applied.[48]

Amphetamine concentrations in influent wastewaters ranged from 7.20 ng/L (Trabzon Değirmendere WWTP) to 56.93 ng/L (İstanbul Ambarlı WWTP). Removal rates at the six plants employing biological treatment ranged from 84.77% to 100%, with complete removal (100%) achieved at İstanbul Ambarlı WWTP, Antalya Hurma WWTP, Samsun Doğu WWTP, and İzmir Çiğli WWTP. At Trabzon Değirmendere WWTP, which does not employ biological treatment, removal was limited to just 13.20%. The biodegradability of amphetamine in activated sludge processes is consistent with the high removal efficiencies observed at plants employing advanced treatment. A study conducted on wastewater in South Australia reported that amphetamine removal varied depending on the treatment process, with incomplete removal occasionally occurring even during secondary treatment.[49]

Methamphetamine exhibited the highest influent concentrations among the psychoactive substances measured in the study. Influent wastewater concentrations ranged from 22.51 ng/L (Hatay–İskenderun WWTP) to 409.23 ng/L (İstanbul Ambarlı WWTP). Removal rates at plants employing biological treatment ranged from 90.1% to 95.3%; however, residual methamphetamine was detected in the effluents of İstanbul Ambarlı WWTP and İzmir Çiğli WWTP at concentrations of 29.37 ng/L and 17.00 ng/L, respectively. At Trabzon Değirmendere WWTP, removal was limited to just 5.8% despite mechanical pretreatment, and the effluent from this plant discharged a substantial methamphetamine load into the receiving environment. Verma et al. (2025) reported global influent methamphetamine concentrations ranging from 6.51 to 7 ng/L and emphasised that removal rates vary considerably depending on treatment type and seasonal conditions. They also highlighted the necessity of advanced treatment methods to prevent the transfer of residual methamphetamine in effluents to receiving environments.[50] Although the value of 409.23 ng/L measured at İstanbul Ambarlı in the present study exceeds this reported global range, the residual concentration of 29.37 ng/L detected in the effluent is noteworthy. A study covering five different wastewater treatment plants in China found that methamphetamine was partially resistant to biological treatment and posed a moderate-to-high environmental risk to water bodies.[51]

Influent watewater concentrations of MDMA (3,4-methylenedioxymethamphetamine) ranged from below the LOQ (Samsun Doğu WWTP) to 42.40 ng/L (İstanbul Ambarlı WWTP). At Samsun Doğu WWTP, removal could not be calculated because the influent concentration was below the LOQ. Even at plants employing advanced biological treatment, removal rates were below expectations, ranging from 8.6% (Adana Seyhan) to 71.5% (İstanbul Ambarlı). The particularly low removal rate of 7.56% observed at Adana Seyhan indicates that the process conditions at this plant may not be conducive to MDMA transformation. The known partial resistance of MDMA to biological treatment is consistent with the low-to-moderate removal efficiencies observed across the plants. Melones-Peña et al. (2025) reported MDMA removal rates of 32–57% at conventional treatment plants and rates exceeding 85% with advanced treatment (ozonation + activated carbon). They also reported that MDMA concentrations in secondary treatment effluents remained within the range of 2–267 ng/L (median: 56 ng/L).[52] The removal value reported for Adana Seyhan WWTP in the present study (8.6% removal) falls below the lower end of this reported global range, indicating a process-specific limitation.

Benzoylecgonine, the primary urinary metabolite of cocaine, represents one of the most notable findings of the study. The highest influent concentrations were measured at İzmir Çiğli WWTP (382.05 ng/L), İstanbul Ambarlı WWTP (344.68 ng/L), and Antalya Hurma WWTP (325.59 ng/L). At plants employing advanced biological treatment, removal rates ranged from 92.2% to 100%, with near-complete removal achieved at Samsun Doğu WWTP and İzmir Çiğli WWTP. At Trabzon Değirmendere WWTP, which employs a physical pretreatment process, benzoylecgonine removal was determined to be only −12.65%, clearly demonstrating the adverse effect of the absence of biological treatment on the removal of this cocaine metabolite. Furthermore, part of the increase in benzoylecgonine concentrations in the effluent may be explained by the hydrolytic conversion of cocaine into benzoylecgonine. Globally, influent concentrations have been reported to range from 9 to 7,500

48 Meena K. Yadav et al., "Occurrence, Removal and Environmental Risk of Markers of Five Drugs of Abuse in Urban Wastewater Systems in South Australia," *Environmental Science and Pollution Research 26* (2019): 33816–33826, https://doi.org/10.1007/s11356-018-2464-6.

49 Yadav et al., "Occurrence, Removal and Environmental Risk."

50 Akshita Verma et al., "Environmental Fate of Illicit Drugs and New Psychoactive Substances in Aquatic Systems: Impact, Critical Insights, and Future Directions," *Environmental Toxicology and Pharmacology 120* (2025): 104880, https://doi.org/10.1016/j.etap.2025.104880.

51 Jie Zhao et al., "In Five Wastewater Treatment Plants in Xinjiang, China: Removal Processes for Illicit Drugs, Their Occurrence in Receiving River Waters, and Ecological Risk Assessment," *Chemosphere 339* (2023): 139668, https://doi.org/10.1016/j.chemosphere.2023.139668.

52 Natalia Melones-Peña et al., "Ecotoxicological Risk and Seasonal Removal of Licit and Illicit Drugs in Wastewater Treatment Plants: A Comparison of Secondary and Tertiary Processes," *Journal of Hazardous Materials 499* (2025): 140290, https://doi.org/10.1016/j.jhazmat.2025.140290.

ng/L, while removal rates of 42–99% have been reported for conventional activated sludge processes.[53] The influent concentrations of 325–382 ng/L obtained in the present study fall within the upper-middle range of the global distribution. A study conducted at wastewater treatment plants in Valencia, Spain, demonstrated that benzoylecgonine was consistently detected and that removal rates increased markedly in the presence of biological treatment.[54]

Influent wastewater concentrations of THC-COOH, the primary urinary metabolite of cannabis, ranged from 11.52 ng/L (Samsun Doğu WWTP) to 88.98 ng/L (Adana Seyhan WWTP). At plants employing advanced biological treatment, effluent wastewater concentrations fell below the LOQ, corresponding to complete or near-complete removal. Removal reached 100% at Hatay–İskenderun WWTP, which employs the UCT process, and 96.0% at Adana Seyhan WWTP. At Trabzon Değirmendere WWTP, THC-COOH removal was limited to just 6.30%, clearly demonstrating the persistence of the metabolite in the absence of biological treatment. The high influent concentration measured at Antalya Hurma (88.98 ng/L) may reflect the city's tourism intensity and seasonal population fluctuations. Due to its hydrophobic nature, THC-COOH is largely adsorbed onto sludge and settles with particulate matter during treatment. Therefore, interpreting removal solely as degradation is not sufficient, and transfer to sludge must also be taken into account. Verovšek et al. (2023) reported an average THC-COOH removal rate of approximately 65% at wastewater treatment plants, noting that the metabolite exhibits moderate susceptibility to biological treatment and persists in surface waters.[55] The below-LOQ effluent concentrations observed at plants employing biological treatment in the present study indicate substantially higher performance than this reported average, confirming the superior effectiveness of advanced treatment technologies in removing THC-COOH.

Cotinine, the primary metabolite of nicotine, reached the highest concentrations among the compounds investigated in the study. Influent concentrations ranged from 1,350 ng/L (Samsun Doğu WWTP) to 10,841 ng/L (İstanbul Ambarlı WWTP), clearly demonstrating how active cigarette smoking in Türkiye is reflected in the

53 Melones-Peña et al., "Ecotoxicological Risk and Seasonal Removal."



54 María Jesús Andrés-Costa et al., "Occurrence and Removal of Drugs of Abuse in Wastewater Treatment Plants of Valencia (Spain)," *Environmental Pollution 194* (2014): 152–162, https://doi.org/10.1016/j.envpol.2014.07.019.

55 Verovšek et al., "Removal of Residues of Psychoactive Substances."

wastewater pollutant load. At all plants employing biological treatment, effluent wastewater concentrations of cotinine fell below the LOQ (1 ng/L), and complete removal was achieved. At Trabzon Değirmendere WWTP, which lacks biological treatment, the effluent concentration exceeded the influent concentration (negative removal, −7.38%). This may be explained by the release of free cotinine through the hydrolysis of conjugated metabolites during physical pretreatment. The complete removal achieved through biological treatment in this study is particularly significant given the high concentrations observed, while the negative removal at Trabzon is especially concerning in terms of risks to the receiving environment. Khan and Nicell (2015) drew attention to nicotine-related compounds among the pharmaceutically active compounds that may remain in drinking water after treatment and emphasised that cotinine may persist in systems where complete biological treatment is not applied.[56]

Ethyl sulfate, a specific and stable biomarker of alcohol consumption, was the second-highest-concentration compound examined in the study. Influent concentrations ranged from 1,394 ng/L (Samsun Doğu WWTP) to 7,509 ng/L (Antalya Hurma WWTP). This high value, which may be associated with elevated alcohol consumption linked to tourism in Antalya, reflects the spatiotemporal patterns of urban consumption profiles in the context of wastewater-based epidemiology (WBE). At all plants employing biological treatment, ethyl sulfate concentrations in the effluent fell below the LOQ (1.0 ng/L), and removal was practically complete. At Trabzon Değirmendere WWTP, negative removal (−2.80%) was recorded, as was the case for cotinine. This finding suggests that, in the absence of biological treatment, the hydrolysis of conjugated metabolites may affect both cotinine and ethyl sulfate concentrations. Melones-Peña et al. (2025) reported that ethyl sulfate removal exceeded 85% during tertiary treatment and that it was not expected to pose an ecotoxicological risk at current environmental concentrations.[57] Although the results of the present study are consistent with these findings, the negative removal observed in Trabzon highlights the potential impact of conjugated metabolite hydrolysis on surface water pollution. A study conducted in Europe demonstrated that ethyl sulfate concentrations varied considerably between weekdays and weekends and during periods of high tourist activity, indicating that these variations provide a useful pattern for monitoring alcohol consumption through WBE.[58]

Caffeine had the highest influent concentrations among all compounds measured in the study. Influent concentrations ranged from 174,041 ng/L (Samsun Doğu WWTP) to 919,690 ng/L (İzmir Çiğli WWTP), with the latter exceptionally high value reflecting the contribution of daily caffeine consumption by large populations to wastewater loads. At the six plants employing biological treatment, caffeine removal efficiency ranged from 98.2% to 99.4%, making caffeine the compound with the highest removal rates across all biologically treated wastewater. At Trabzon Değirmendere WWTP, however, removal was limited to 56.20%, and the inadequacy of physical pretreatment for caffeine removal resulted in high residual concentrations in the effluent. The high removal efficiency of caffeine during wastewater treatment demonstrates its biodegradability and underscores its importance as an anthropogenic indicator of human activities. A comparative study reported caffeine removal rates exceeding 85% at plants employing secondary and tertiary treatment.[59] The removal rates of 98–99% achieved at plants with biological treatment processes in the present study are considerably higher than this lower threshold, confirming the high effectiveness of activated sludge processes in removing caffeine in Türkiye. Verovšek et al. (2023) documented the widespread global distribution of caffeine as a wastewater-derived pollutant and demonstrated that measurable concentrations may persist in water bodies receiving effluent from plants without biological treatment or with insufficient treatment capacity.[60]

56 Usman Khan and Jim Nicell, "Human Health Relevance of Pharmaceutically Active Compounds in Drinking Water," *The AAPS Journal* 17 (2015): 558–585, https://doi.org/10.1208/s12248-015-9729-5.

57 Melones-Peña et al., "Ecotoxicological Risk and Seasonal Removal."

58 Verovšek et al., "Removal of Residues of Psychoactive Substances."

59 Sian E. Evans et al., "Determination of Chiral Pharmaceuticals and Illicit Drugs in Wastewater and Sludge Using Microwave Assisted Extraction, Solid-Phase Extraction and Chiral Liquid Chromatography Coupled with Tandem Mass Spectrometry," *Analytica Chimica Acta 882* (2015): 112–126, https://doi.org/10.1016/j.aca.2015.03.039.

60 Verovšek et al., "Removal of Residues of Psychoactive Substances."

Table 1. Removal Efficiency Values for Conventional Parameters and Psychoactive Substances

	BOD	COD	Morphine	Amphetamine	Methamphetamine	MDMA	Benzoylecgonine	THC-COOH	Cotinine	Ethylsulfate	Caffeine
Samsun Doğu WWTP Samsun · Advanced Biological	91.0	90.4	≥ 99.5	≥ 99.5	95.3	—	99.0	≥ 99.5	≥ 99.5	≥ 99.5	99.4
İstanbul Ambarlı WWTP İstanbul · Advanced Biological	97.9	89.3	≥ 99.5	≥ 99.5	76.4	36.1	96.6	≥ 99.5	≥ 99.5	≥ 99.5	99.0
Hatay İskenderun WWTP Hatay · Biological (UCT)	90.1	88.2	81.6	93.6	90.0	72.4	93.4	≥ 99.5	≥ 99.5	≥ 99.5	99.4
Antalya Hurma WWTP Antalya · Advanced Biological (Bardenpho)	95.7	93.2	92.2	≥ 99.5	90.1	23.7	97.2	90.8	≥ 99.5	≥ 99.5	99.2
İzmir Çiğli WWTP İzmir · Advanced Biological	90.4	90.0	≥ 99.5	≥ 99.5	89.5	4.8	98.9	≥ 99.5	≥ 99.5	≥ 99.5	98.2
Adana Seyhan WWTP Adana · Biological (Activated Sludge)	82.6	83.2	91.8	84.8	93.2	7.6	70.3	96.0	≥ 99.5	≥ 99.5	99.2
Trabzon Değirmendere WWTP* Trabzon · Physical Pre-Treatment	—	—	3.9	13.2	-0.9	60.2	-12.7	6.3	-7.4	-2.8	56.2

≤ 0% ≤0 25 50 75 100% 100% <LOQ → 100% (below detection limit) No data

* Trabzon Değirmendere WWTP operates a physical pre-treatment + deep-sea outfall system; no biological treatment is performed. Negative removal values indicate a concentration increase (e.g., hydrolysis of conjugated metabolites).

** Adana Seyhan MDMA value was affected by high influent variability. Samsun Doğu MDMA concentration in influent remained below the detection limit.

4.3.4. Interpretation in Terms of Environmental Health

The research findings clearly demonstrate the decisive role of the presence or absence of biological treatment in the removal of psychoactive substances. Plants employing advanced biological treatment generally achieve removal rates of >90%, whereas Trabzon Değirmendere WWTP, which relies on physical pretreatment and deep-sea discharge, presents a markedly higher risk than the other plants in terms of transporting psychoactive substances into the Black Sea. In particular, the detection of methamphetamine at Trabzon at a concentration of 53.28 ng/L in the effluent wastewater, with a removal rate of only 5.8%, constitutes a priority environmental health concern requiring preventive measures.

The detection of methamphetamine (İstanbul Ambarlı: 29.37 ng/L; İzmir Çiğli: 17.00 ng/L) and MDMA at measurable concentrations in the effluent wastewaters of plants employing biological treatment indicates that these substances may reach receiving water environments. Psychoactive substances entering seas and rivers through treated wastewater discharges may pose risks to aquatic ecosystems, depending on discharge conditions (including deep-sea discharge depth and pipeline length, as well as the dilution capacity of the receiving environment) and the characteristics of the receiving environment. The fact that treated effluent from Adana Seyhan WWTP is ultimately discharged into the Mediterranean Sea via the Seyhan River imposes an additional pressure on river habitats.

Environmental Risk Assessment

To assess the ecological risks posed by psychoactive substances to aquatic ecosystems, it is necessary to compare the predicted environmental concentration (PEC) with the predicted no-effect concentration (PNEC). The environmental risk associated with persistent compounds in wastewater treatment plant effluents can be assessed using the risk quotient (RQ = PEC/PNEC) approach. RQ < 0.1 is defined as low risk, 0.1 ≤ RQ < 1.0 as moderate risk, and RQ ≥ 1.0 as high risk. For PEC calculations, the effluent concentrations measured in this study were divided by the estimated dilution capacity of the receiving environment to establish realistic and conservative dilution scenarios. The dilution factors were considered to vary according to the location of the plant's discharge point, the hydrological characteristics of the receiving environment (river, gulf, or open sea), and seasonal flow rates.

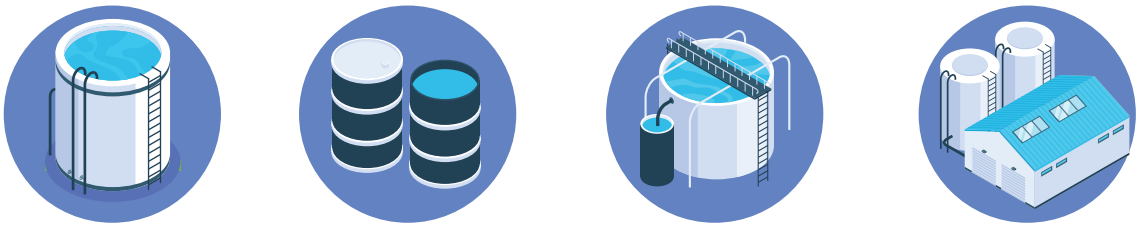
Ecotoxicological databases compiled from the literature were used to establish the PNEC reference values in this study.[61] The PNEC was determined as 6–10 ng/L for methamphetamine (based on acute and chronic toxicity studies in fish), 216 ng/L for MDMA (Daphnia magna NOEC), 500 ng/L for benzoylecgonine (Daphnia magna LOEC), 100 ng/L for cotinine (ECOSAR-predicted EC_{50}, based on neurotoxicity data), and 90 ng/L for amphetamine. Although PNEC values for morphine, THC-COOH, and ethyl sulfate are associated with wider uncertainty ranges, these substances are predicted to pose low-to-moderate risks at current environmental concentrations.

Receiving Environment Discharge Scenarios and Predicted Effects Analysis

The effluents of wastewater treatment plants are discharged into different receiving environments (rivers, gulfs, and open seas), and both dilution capacity and the sensitivity of the receiving environment vary considerably from one plant to another. Two contrasting scenarios are presented below for the receiving environments of plants posing environmental risks, under conservative (low-dilution) and plausible (moderate-dilution) conditions.

Trabzon Değirmendere WWTP discharges its treated effluent into the Black Sea through a 1,500 m long deep-sea outfall pipeline. Even considering the sea's high dilution capacity, the methamphetamine concentration in the plant's effluent (53.28 ng/L) represents a significant risk scenario. Under the conservative scenario (10× dilution, low-flow conditions, and stratification due to the thermocline effect), the predicted receiving environment concentration was calculated as 5.33 ng/L. Although this value is close to the lower bound of the methamphetamine PNEC (6–10 ng/L), it falls within a range of potential concern and corresponds to a moderate environmental risk level (RQ ≈ 0.53–0.89). Under the plausible scenario (100× dilution under complete mixing conditions), the predicted receiving environment concentration is 0.53 ng/L, corresponding to a low environmental risk (RQ ≈ 0.05–0.09). For cotinine, the predicted receiving environment concentration under the plausible scenario (100× dilution under complete mixing conditions) was calculated as 14.35 ng/L, indicating

61 Melones-Peña et al., "Ecotoxicological Risk and Seasonal Removal"; R. Yedhu Krishnan et al., "Origin, Transport and Ecological Risk Assessment of Illicit Drugs in the Environment – A Review," *Chemosphere 311*, part 2 (2023): 137091, https://doi.org/10.1016/j.chemosphere.2022.137091.



a moderate environmental risk (RQ ≈ 0.14). Under the conservative scenario (10× dilution), however, a high environmental risk (RQ > 1) is predicted. The Black Sea constitutes a more sensitive receiving environment than the Mediterranean due to its relatively low salinity and limited vertical mixing. Furthermore, the negative removal of cotinine and ethyl sulfate observed in Trabzon (effluent concentrations exceeding influent concentrations) indicates that the hydrolysis of conjugated metabolites results in an additional pollutant load, suggesting that the actual discharge load may be higher than that measured using the available data. Studies have reported an increasing frequency of detection of biological stress biomarkers associated with psychoactive substances in aquatic organisms in the Black Sea basin, emphasising that filter-feeding invertebrates such as Dreissena polymorpha are sensitive bioindicators of metabolic disorders and genotoxicity.[62] The widespread presence of these organisms along the Black Sea coast and in the vicinity of Trabzon makes them important for monitoring the cumulative effects of deep-sea discharge on regional biota.

İstanbul Ambarlı WWTP is one of the largest treatment plants discharging into the Sea of Marmara. Despite the implementation of biological treatment (MBR + UV), residual methamphetamine and MDMA detected in the effluent are noteworthy. Given the relatively semi-enclosed nature of the Sea of Marmara and its limited water renewal time (approximately six months), there is a risk of accumulation near the discharge point. Under the conservative scenario (50× dilution), the predicted receiving environment concentration of methamphetamine was estimated at 0.59 ng/L, corresponding to a low-to-moderate risk level (RQ ≈ 0.06–0.10). Under the plausible scenario (200× dilution, open-sea conditions), the predicted receiving environment concentration was estimated at 0.15 ng/L, indicating low risk (RQ < 0.03). For MDMA (effluent concentration ≈ 12.02 ng/L, following 71.5% removal), the predicted receiving environment concentration under the conservative scenario was calculated as 0.24 ng/L, corresponding to a very low acute risk (RQ = 0.001). Nevertheless, İstanbul's influent methamphetamine concentrations reaching 409 ng/L and the continuous discharge associated with its large population underscore the need for long-term monitoring when considering the cumulative load transported into the Sea of Marmara. A study investigating the presence of illicit drug-related pollutants in Türkiye's coastal waters reported increased concentrations in coastal habitats, particularly those near densely populated urban areas.[63]

Adana Seyhan WWTP discharges its treated effluent into the Seyhan River via the DSİ TD8 drainage channel, and this water ultimately reaches the Mediterranean Sea. Compared with open-sea discharge, river discharge offers a much more limited dilution capacity, making it a particularly critical scenario in terms of ecological risk. MDMA removal at Adana Seyhan was only 8.6%, with an influent wastewater concentration of 25.13 ng/L and an effluent wastewater concentration of 22.96 ng/L. Under the conservative scenario (10× dilution in the river under low summer-flow conditions), the predicted receiving environment concentration was calculated as 3.88 ng/L, corresponding to low risk (RQ = 0.018). For benzoylecgonine, the effluent concentration at Adana Seyhan was 96.72 ng/L. Under the conservative scenario, the predicted receiving environment concentration was calculated as 9.67 ng/L, indicating low risk (RQ = 0.019). A study conducted in the Seyhan River measured benzoylecgonine concentrations ranging from 0.158 to 0.498 ng/L. These values are consistent with dilution in the river downstream of the WWTP effluent and indicate that the transfer of this cocaine metabolite continues along the river.[64]

İzmir Çiğli WWTP stands out for having the highest measured influent caffeine concentration (919,690 ng/L), which decreases to 14.18 ng/L following biological treatment. The effluent wastewater from İzmir Çiğli WWTP

62 Halina Falfushynska et al., "Illicit Drugs in Surface Waters: How to Get Fish off the Addictive Hook," *Pharmaceuticals 17*, no. 4 (2024): 537, https://doi.org/10.3390/ph17040537.

63 Senar Aydın, Arzu Ulvi, and Mehmet Emin Aydın, "Monitoring and Ecological Risk of Illegal Drugs before and after Sewage Treatment in an Area," *Environmental Monitoring and Assessment 194* (2022): 294, https://doi.org/10.1007/s10661-022-09974-x.

64 Evsen Yavuz Güzel, Fatma Çevik, and Nebile Dağlıoğlu, "The Occurrence and Seasonal Variations of Cocaine and Its Main Metabolite Benzoylecgonine, in Seyhan River, Turkey," *3rd Regional TIAFT Meeting in Turkey*, Nevşehir, Türkiye, 18–20 October 2018, 114–120.

also contains a residual methamphetamine concentration of 17.00 ng/L. The Gulf of İzmir is a semi-enclosed body of water with a more limited dilution capacity than the open Aegean Sea. Under the conservative scenario, which assumes 30-fold dilution in the inner parts of the gulf, the predicted environmental concentration of methamphetamine was calculated as 0.57 ng/L. This corresponds to a low-to-moderate environmental risk (RQ ≈ 0.06–0.10). Complete removal of benzoylecgonine (100%) was achieved at İzmir Çiğli, with the effluent concentration falling below the LOQ. Therefore, the associated environmental risk was considered negligible. Overall, the high biological treatment performance at İzmir Çiğli ensures acceptable levels of environmental risk for the gulf. Nevertheless, continued seasonal monitoring of residual methamphetamine is recommended.

The effluent from Antalya Hurma WWTP is discharged into the Mediterranean Sea. The plant achieved a relatively low MDMA removal rate of 23.7%, with an influent concentration of 23.00 ng/L and an effluent concentration of 16.58 ng/L. The influent concentration of THC-COOH was the highest among all plants, at 88.98 ng/L. However, complete removal was achieved through advanced treatment. Under the conservative scenario for MDMA, which assumes 50-fold dilution in coastal Mediterranean waters, the predicted environmental concentration was calculated as 0.65 ng/L, indicating a very low environmental risk (RQ = 0.003). Antalya Hurma also recorded the highest influent ethyl sulfate concentration among all plants, at 7,509 ng/L. Following biological treatment, the effluent wastewater concentration fell below the LOQ (1 ng/L), and the associated environmental risk in the receiving environment was considered negligible.

A study covering five wastewater treatment plants in four European countries reported that RQ values for methamphetamine and amphetamine in secondary treatment effluents occasionally exceeded 1, indicating a high environmental risk. This finding suggests that existing biological treatment capacity may be insufficient for the removal of psychoactive substances.[65] A study evaluating data from Asia and Europe identified methamphetamine as the compound with the highest environmental risk potential and highlighted findings of addictive behaviour and reproductive suppression in fish exposed to environmental concentrations of the substance.[66] Verma et al. (2025) drew attention to the inadequacy of existing PNEC data for assessing the ecotoxicological risks of psychoactive substances. They also highlighted the urgent need for data on receiving environments in countries such as Türkiye, particularly in tropical and semi-arid climate regions.[67]

4.3.5. General Environmental Assessment and Policy Recommendations

An integrated assessment of the predicted environmental concentration scenarios indicates that the receiving environments of the six plants employing biological treatment remain within acceptable ecological risk limits under current conditions. However, three critical findings require urgent attention at the policy level. (i) Due to the absence of biological treatment, Trabzon Değirmendere WWTP discharges methamphetamine, cotinine, and ethyl sulfate into the Black Sea at concentrations approaching critical levels. Under conservative predicted scenarios, moderate-to-high risk levels are calculated for methamphetamine. (ii) MDMA exhibits low removal efficiencies even at plants employing biological treatment, indicating that existing secondary treatment technologies may be insufficient for this compound and necessitating the evaluation of tertiary treatment options such as ozonation and activated carbon adsorption. (iii) The discharge of residual methamphetamine from İstanbul Ambarlı WWTP into the Sea of Marmara necessitates a long-term monitoring programme to assess cumulative accumulation in this semi-enclosed basin.

Tertiary treatment options, including ozonation combined with granular activated carbon (GAC), increase methamphetamine and MDMA removal efficiencies to above 85% and substantially reduce environmental risks in receiving environments compared with secondary treatment.[68] This finding provides a concrete technological reference for strengthening treatment capacity, particularly at Adana Seyhan and Antalya Hurma WWTPs, where MDMA removal has proved inadequate.

In conclusion, the predicted scenario analyses presented in this study indicate that psychoactive substance discharges may pose environmental risks to receiving water environments in Türkiye, particularly along the Black

65 Melones-Peña et al., "Ecotoxicological Risk and Seasonal Removal."
66 Krishnan et al., "Origin, Transport and Ecological Risk Assessment of Illicit Drugs."
67 Verma et al., "Environmental Fate of Illicit Drugs and New Psychoactive Substances."
68 Melones-Peña et al., "Ecotoxicological Risk and Seasonal Removal."

Sea coast near Trabzon and in the Seyhan River in Adana. Implementing an integrated monitoring programme that combines receiving environment monitoring data, seasonal flow measurements, and biological effect studies is essential to verify and mitigate these risks. Strengthening the wastewater monitoring infrastructure established under Türkiye's 2024–2028 Action Plan for Combating Drugs with this integrated ecotoxicological dimension would constitute a critical step forward in both public health and environmental policy. In light of these findings, strengthening the treatment infrastructure at Trabzon Değirmendere WWTP emerges as a priority policy objective.

4.3.6. **Public Health Policy Recommendations**

The findings of this study demonstrate that psychoactive substance concentrations and removal efficiencies can be assessed comparatively across wastewater treatment plants with different treatment capacities. Repeated measurements at regular intervals would contribute to monitoring seasonal variations, detecting potential shifts in consumption patterns at an early stage, and assessing the effectiveness of treatment technologies under real-world conditions. In this regard, the study provides a concrete rationale for expanding and sustaining the wastewater monitoring programme implemented under the 2024–2028 Action Plan for Combating Drugs.

The research findings also highlight several critical research priorities. The relatively low removal rates of MDMA, even with advanced biological treatment, underscore the need for studies investigating the adequacy of existing treatment technologies for this compound. During the wastewater treatment process, deconjugation, desorption from sludge, and hydraulic retention time, which may cause influent and effluent samples to represent different wastewater volumes, must not be overlooked when interpreting the results. Furthermore, the high benzoylecgonine concentrations observed in coastal cities make it a priority to examine cocaine consumption in these cities in greater detail using consumption estimates supported by wastewater data.

Several important limitations must also be considered when evaluating the contribution of these findings to public health policy. The study is based on only seven days of measurements at each plant, meaning that seasonal patterns and long-term trends could not be assessed using the available data. Since sampling at all plants was conducted during a single week, controlling for seasonal effects in comparisons between plants is challenging. In addition, the present study does not include Türkiye-specific data on the metabolic correction factors required to calculate consumption estimates. Other limitations include daily variations in the populations served by the plants, the stability of substances within sewer systems, and constraints and uncertainties associated with flow measurements. The inability to measure the effects of discharged effluent on the receiving environment constitutes another limitation of the study. Finally, in accordance with the principles of individual privacy and ethical data use, any attempt to identify individual consumers or draw conclusions about patterns of criminal activity from these data must be avoided. The findings may be used exclusively to inform policy development at the population level. Addressing these limitations requires strengthening the monitoring programme through standardised procedures, regular measurements, and an infrastructure that supports interinstitutional data sharing.



CHAPTER 5: **POLICY RECOMMEN-DATIONS**

- The relationship between climate change, addictions, and public health should be recognised as a shared policy area in health, environmental, and social policy documents. The One Health and Planetary Health approaches should be placed on the agenda of the High Council for Combating Addictions and integrated into national action plans and strategies for combating addiction, thereby preventing the escalation of environmental costs.
- In collaboration with the Ministry of Health, the Turkish Statistical Institute (TurkStat), AFAD, and the Ministry of Environment, Urbanisation and Climate Change, national "addiction and climate vulnerability maps" should be developed to monitor the effects of climate change on addiction risks.
- Psychosocial support, mental health services, and addiction prevention programmes should be jointly implemented by AFAD, the Ministry of Health, and the Ministry of Family and Social Services in regions affected by disasters, droughts, heatwaves, and environmental crises.
- Addiction treatment and rehabilitation services should be supported by disaster preparedness and business continuity plans to ensure their resilience to climate-related disasters and extreme weather events.
- It should be recognised that children and young people are among the groups most vulnerable to both the climate crisis and the effects of addiction industries. Climate and addiction policies should therefore be addressed together from a child rights perspective.
- In line with the approach adopted in Türkiye's Emissions Trading System Regulation, prepared by the Ministry of Environment, Urbanisation and Climate Change to encourage relevant sectors to bear their environmental costs, similar accountability mechanisms should be developed to address the environmental impacts of addictive products and services.[1] Industries producing addictive products and providing addictive services should be required to report on environmental harm, including their carbon and water footprints and deforestation.
- The costs of environmental cleanup, waste management, and ecosystem restoration arising from addictive products and services should be borne by the relevant industries. The principles of "Extended Producer Responsibility" and "the Polluter Pays Principle" should also be applied globally to addictive products and services.[2]
- Environmental damage caused by addictive products and services should be treated as a distinct category of violation under environmental legislation and the Law on Misdemeanours, rather than being addressed solely under the relevant underlying criminal offence or misdemeanour. Depending on the nature and extent of the environmental damage, administrative fines, environmental rehabilitation, ecosystem restoration, and obligations to remedy the damage should be imposed.
- Environmental improvement claims made by tobacco and alcohol companies should be subject to independent verification mechanisms. The use of environmental sustainability narratives in tobacco and alcohol marketing for greenwashing purposes, or as a means of indirect promotion and legitimisation through corporate social responsibility projects, should be prevented.
- Producer responsibility should be the guiding principle to prevent environmental responsibility from being shifted onto consumer behaviour. Companies should be required to disclose not only selected environmental indicators but also the environmental impacts of their products throughout their entire life cycle.
- Tobacco and alcohol industries should be prevented from participating in COP processes as sponsors, partners, or policy stakeholders and should be excluded from decision-making processes in accordance with conflict-of-interest principles.

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1 Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, *Türkiye Emisyon Ticaret Sistemi Yönetmeliği*, Resmî Gazete, Sayı: 33353, 27 Ağustos 2026, https://www.resmigazete.gov.tr/ (Erişim Tarihi: 14 Ekim 2026).

2 Under the European Union's (EU) "Extended Producer Responsibility" framework, tobacco companies are required to bear the costs of cigarette butt cleanup and waste management as an important policy instrument for environmental improvement. Some member states have directly assigned the management of cigarette butt waste and the development of awareness-raising measures to the tobacco industry (e.g., France). See European Parliament, "Question for Written Answer E-9-2023-001303," 2023, https://www.europarl.europa.eu/doceo/document/E-9-2023-001303_EN.html Accessed: 9 June 2026.

- Environmental education and awareness-raising activities addressing issues such as water, soil, and air pollution, conducted by environmental organisations, non-governmental organisations, and organisations working in the field of addiction, should also incorporate the environmental impacts of addictions. Educational modules addressing the relationship between environmental health and addiction should be developed from primary school onwards to strengthen public awareness.
- Community-based prevention programs and awareness campaigns should be expanded to address not only the health impacts of addictions but also their effects on the environment and climate.
- Prevention programs should be strengthened by incorporating components on climate change adaptation, psychological resilience, and environmental awareness. Performance indicators should be developed to assess the environmental impacts of the Green Crescent Addiction Prevention Training Program (TBM) and similar programs.
- Addiction prevention should be considered an integral component of sustainable development and planetary health objectives. The environmental co-benefits of addiction prevention should be measured and reported in both national and international strategies.
- Educational programs that strengthen climate anxiety management, stress management, resilience, and healthy coping skills among children and young people should be expanded. Life skills education for young people should address the relationship between the climate crisis, environmental sustainability, and addiction in an integrated manner.
- Wastewater-based surveillance systems should be expanded to monitor the consumption of psychoactive substances, emerging synthetic substances, alcohol, and nicotine.
- Wastewater-based epidemiology practices should be institutionalized at the national level, with findings published regularly. Results obtained from wastewater analyses should be shared through common data platforms among health, environmental, and security institutions.
- Wastewater-based epidemiology data should be assessed alongside health and socioeconomic indicators and integrated into artificial intelligence-supported early warning and monitoring systems. This would enable emerging substance use trends, regional risks, and environmental impacts associated with addiction to be identified in advance, thereby strengthening risk mapping and policymaking processes.
- The use of advanced treatment technologies to remove psychoactive substance residues should be made a legal requirement for local authorities and relevant administrative bodies at facilities discharging wastewater into the sea, rivers, and other surface water resources, as well as onto land.

Policy Recommendations on Tobacco Addiction

- Dedicated waste management systems should be established to address cigarette butt pollution. Special collection systems for cigarette butts should be expanded by the Ministry of Environment, Urbanization and Climate Change and local authorities, with manufacturers held responsible for cleaning and disposal costs.
- Awareness campaigns should be conducted under the coordination of the Ministry of Environment, Urbanization and Climate Change, with contributions from the Ministry of Health, local authorities, and civil society organizations, to raise public awareness that cigarette butts are among the most common types of litter discarded into the environment.
- Information on the water footprint, carbon footprint, and environmental impacts of tobacco products should be provided on product labels.
- The gradual phase-out or restriction of cigarette filters and tobacco products containing single-use plastics should be incorporated into national tobacco action plans as a responsibility of the Ministry of Environment, Urbanization and Climate Change.
- The impacts of tobacco cultivation on deforestation, water consumption, and pesticide use should be monitored regularly, and environmental impact assessments should be made mandatory.

Policy Recommendations on Alcohol Addiction

- Carbon footprint, water footprint, and wastewater management reporting should be made mandatory for alcoholic beverage manufacturers, with reports submitted to the Ministry of Environment, Urbanization and Climate Change.
- In regions with intensive alcohol production, the Ministry of Agriculture and Forestry should ensure that pressure on water resources is monitored and that water efficiency criteria are incorporated into agricultural permitting processes.
- Environmental impact labelling practices that make the environmental costs of alcoholic beverages visible should be made mandatory for alcohol product packaging.
- Although the expansion of closed-loop water systems, energy efficiency measures, and renewable energy use in alcohol production facilities, together with the strengthening of recycling systems for packaging waste, may contribute to reducing environmental impacts, it should be recognized that the priority approach to most effectively reducing the environmental burden associated with addiction is the implementation of protective and preventive policies aimed at reducing alcohol consumption and the associated production demand.

Policy Recommendations on Substance Addiction

- Coordination among environmental, forestry, water management, public health, and law enforcement agencies should be strengthened to monitor deforestation, land degradation, and chemical pollution resulting from psychoactive substance production. Environmental crimes and drug-related offenses should be addressed within an integrated monitoring and intervention framework.
- Specialized response teams should be established by the Ministry of Interior, the Ministry of Environment, Urbanization and Climate Change, and AFAD to detect and clean up chemical waste originating from illicit drug laboratories. International data sharing and joint monitoring mechanisms concerning the environmental impacts of psychoactive substance production and trafficking should be strengthened.
- Focusing solely on reducing supply and demand is insufficient for drug control policies. Ecosystem restoration and rehabilitation activities should be made a mandatory component of drug control strategies, with the Ministry of Agriculture and Forestry and the General Directorate of Forestry responsible for addressing environmental damage in areas where illicit production takes place.
- Efforts to reduce the environmental harm caused by psychoactive substances should not be limited to managing waste such as used syringes, packaging, and similar materials generated after consumption. Protective and preventive policies aimed at reducing substance use, which is the underlying source of the environmental burden, should be prioritized. Accordingly, the prevention of substance addiction should be prioritized over harm reduction strategies and recognized as a fundamental component not only of public health policies but also of environmental protection and sustainable development policies.

Policy Recommendations on Digital Addictions

- The Information and Communication Technologies Authority (ICTA) and the Ministry of Industry and Technology should require major technology companies to publish regular public reports on data center energy consumption, carbon footprints, and water use. Minimum standards should be established for the share of renewable energy used by digital service providers.
- New-generation digital regulations should be developed by assessing the environmental impacts of digital platforms alongside user well-being and addiction risks. Addictive design features on social media, gaming, and artificial intelligence platforms, such as infinite scrolling, autoplay, and excessive notification systems, should be restricted by the Cybersecurity Presidency. Early warning, monitoring, and regulatory systems, including digital usage limits and screen time controls, should be strengthened through artificial intelligence.

- Standards designed to extend the service life of gaming consoles, mobile phones, and other devices should be implemented to reduce electronic waste generation.

Policy Recommendations on Gambling Addiction

- The Ministry of Environment, Urbanization and Climate Change and the Ministry of Treasury and Finance, under the coordination of the Spor Toto Organization Presidency, should introduce mandatory reporting requirements for online gambling (legal betting) platforms covering energy consumption, carbon footprints, and water consumption.
- The environmental impacts of online gambling (legal betting) platforms arising from data centers should be independently measured and disclosed to the public. These platforms should be regularly audited against environmental sustainability indicators, and an environmental tax category should be introduced for them.
- Policies aimed at preventing gambling addiction should also be considered an environmental policy instrument for reducing increases in energy consumption and digital resource use. The environmental costs generated by the gambling sector should be assessed globally within the framework of environmental taxation mechanisms.

REFERENCES

Abdulwahab, Abdullahi Y., Summayyah B. Muhammad, Audu I. Aveka, Abdulkadir Surajudeen, Sani Khalid, Muhammad Aliyu, Abusufyan Attahiru, Fahad S. Abubakar, and Bashir A. Yakasai. "Climate Variability, Poverty and Substance Use Disorders: Exploring Maladaptive Coping Mechanisms in Climate-Stressed Communities of Northwest Nigeria." *Journal of Public Health in Africa* 17, no. 1 (2026): 1665. https://doi.org/10.4102/jphia.v17i1.1665.

Akter, Shamima, Md Rashedul Islam, Md Mizanur Rahman, Thomas Rouyard, Raïssa Shiyghan Nsashiyi, Fahima Hossain, and Ryota Nakamura. "Evaluation of Population-Level Tobacco Control Interventions and Health Outcomes: A Systematic Review and Meta-Analysis." *JAMA Network Open* 6, no. 7 (2023): e2322341. https://doi.org/10.1001/jamanetworkopen.2023.22341.

American Heart Association. "Greenwashing." Image. *American Heart Association Newsroom*. Accessed: 27 August 2026. https://newsroom.heart.org/file/greenwashing?action=.

Andrés-Costa, María Jesús, Nuria Rubio-López, María Morales Suárez-Varela, and Yolanda Pico. "Occurrence and Removal of Drugs of Abuse in Wastewater Treatment Plants of Valencia (Spain)." *Environmental Pollution 194* (2014): 152–162. https://doi.org/10.1016/j.envpol.2014.07.019.

Asadi, Anvar, Shabnam Zarei, Nebile Daglioglu, Evsen Yavuz Guzel, and Neda Ravankhah. "Illicit Drug Use Derived from Wastewater-Based Epidemiology in Iran, Their Removal during Wastewater Treatment, and Occurrence in Receiving Waters." *Heliyon, 11*, no. 3 (2025): e42516. https://doi.org/10.1016/j.heliyon.2025.e42516.

Asicioglu, F., M. Kuloglu Genc, T. Tekin Bulbul, M. Yayla, S. Z. Simsek, C. Adioren, and S. Mercan. "Investigation of Temporal Illicit Drugs, Alcohol and Tobacco Trends in Istanbul City: Wastewater Analysis of 14 Treatment Plants." *Water Research, 190* (2021): 116729. https://doi.org/10.1016/j.watres.2020.116729.

Ateş, Seyithan Ahmet, Elif Nuroğlu, Hüseyin Hayri Nuroğlu, and Muradiye Ateş. Bağımlılık Ekonomisi: Sigara, Alkol, Kumar ve Uyuşturucu Bağımlılığının Türkiye Ekonomisine Maliyeti. Türkiye Yeşilay Cemiyeti, 2025. https://www.yesilay.org.tr/media/lwrptawz/bagimliligin-ekonomiye-maliyeti-raporu-2025.pdf.

Australian Criminal Intelligence Commission. "National Wastewater Drug Monitoring Program Reports." Accessed: 8 October 2026. https://www.acic.gov.au/publications/national-wastewater-drug-monitoring-program-reports.

Aydın, Senar, Arzu Ulvi, and Mehmet Emin Aydın. "Monitoring and Ecological Risk of Illegal Drugs before and after Sewage Treatment in an Area." *Environmental Monitoring and Assessment 194* (2022): 294. https://doi.org/10.1007/s10661-022-09974-x.

Barkin, J. L., M. Buoli, C. L. Curry, S. A. Von Esenwein, S. Upadhyay, M. B. Kearney, and K. Mach. "Effects of Extreme Weather Events on Child Mood and Behavior." *Developmental Medicine & Child Neurology* 63, no. 7 (2021): 785–790.

Bathie, Laura, Asad Yusoff, Paula O'Brien, Samadhi Hemachandra, Bella Sträuli, Michelle I. Jongenelis, Jacquie Bowden, and Simone Pettigrew. "The Prevalence of Environmental Claims and Recycling Information on Alcohol Products." *Sustainability* 18, no. 2 (2026): 800. https://www.mdpi.com/2071-1050/18/2/800.

Benmarhnia, Tarik. "Commentary on Dennett et al.: When Heat and the Opioid Epidemic Collide—Implications for Climate-Resilient Public Health Strategies." *Addiction* 121, no. 2 (2026): 286–287. https://doi.org/10.1111/add.70302.

Bowen, E. A. "To Change What We Cannot Accept: Acknowledging and Addressing the Impact of Climate Change on Addiction Recovery Capital." *Addiction Research & Theory* 32, no. 6 (2024): 466–476.

Bowes, Devin A., Erin M. Driver, Phil M. Choi, Damiá Barceló, and Paloma I. Beamer. "Wastewater-Based Epidemiology to Assess Environmentally Influenced Disease." *Journal of Exposure Science & Environmental Epidemiology* 34, no. 3 (2024): 387–388. https://doi.org/10.1038/s41370-024-00683-w.

Braveman, Paula, and Laura Gottlieb. "The Social Determinants of Health: It's Time to Consider the Causes of the Causes." *Public Health Reports* 129, suppl. 2 (2014): 19–31. https://doi.org/10.1177/00333549141291S206.

Burke, S. E., A. V. Sanson, and J. Van Hoorn. "The Psychological Effects of Climate Change on Children." *Current Psychiatry Reports* 20, no. 5 (2018): 35.

Burrows, Kate, Christy A. Denckla, Jill Hahn, Jessica E. Schiff, Sakurako S. Okuzono, Hervet Randriamady, Carol Mita, Laura D. Kubzansky, Karestan C. Koenen, and Sarah R. Lowe. "A Systematic Review of the Effects of Chronic, Slow-Onset Climate Change on Mental Health." *Nature Mental Health* 2, no. 2 (2024): 228–243. https://doi.org/10.1038/s44220-023-00170-5.

Butner, Jenna L., Shannon Smith-Bernardin, Joyce Roberson-Steele, Brandee Madden, Valerie A. Gruber, Judith I. Tsui, and Emma T. Biegacki. "The Health Impacts of Climate Change on People Who Use Alcohol and Other Drugs: Position Statement of AMERSA, Inc. (Association for Multidisciplinary Education and Research in Substance Use and Addiction)." *Substance Use & Addiction Journal* 47, no. 4 (2026): 953–958. https://doi.org/10.1177/29767342261461050.

Caddick, Z. A., B. J. Smith, and T. Astell-Burt. "A Systematic Review of Ambient Heat and Sleep in a Warming Climate." *Sleep Medicine Reviews* 75 (2024): 101915. https://doi.org/10.1016/j.smrv.2024.101915.

Chakravorty, S., N. S. Chaudhary, and K. J. Brower. "Alcohol Dependence and Its Relationship with Insomnia and Other Sleep Disorders." *Alcoholism: Clinical and Experimental Research* 42, no. 6 (2018): 1111–1122. https://doi.org/10.1111/acer.13746.

Chang, H. H., H. Zhang, A. D. Latimore, B. P. Murray, R. R. D'Souza, N. Scovronick, M. O. Gribble, and S. T. Ebelt. "Associations Between Short-Term Ambient Temperature Exposure and Emergency Department Visits for Amphetamine, Cocaine, and Opioid Use in California from 2005 to 2019." *Environment International* 181 (2023): 108233. https://doi.org/10.1016/j.envint.2023.108233.

Cheong, Fan and Young-Hee Lee. "Developing an Environmental Management System for Evaluating Green Casino Hotels." *Sustainability* 13, no. 14 (2021): 7825. https://doi.org/10.3390/su13147825.

Chevance, Guillaume, Ujué Fresán, Eric Hekler, Donald Edmondson, Simon J. Lloyd, Joan Ballester, Jill Litt, Ivana Cvijanovic, Vera Araújo-Soares, and Paquito Bernard. "Thinking Health-Related Behaviors in a Climate Change Context: A Narrative Review." *Annals of Behavioral Medicine* 57, no. 3 (2023): 193–204. https://doi.org/10.1093/abm/kaac039.

Clayton, Susan. "Climate Anxiety: Psychological Responses to Climate Change." *Journal of Anxiety Disorders* 74 (2020): 102263. https://doi.org/10.1016/j.janxdis.2020.102263.

Clayton, Susan, and Tara Crandon. "Climate Change and Mental Health." *Annual Review of Clinical Psychology* 21 (2025): 61–83. https://doi.org/10.1146/annurev-clinpsy-081423-025932.

Conference of the Parties to the WHO Framework Convention on Tobacco Control. "Implementation of Article 18 of the WHO FCTC." Decision FCTC/COP10(14), 10 February 2024. https://iris.who.int/server/api/core/bitstreams/a95dd820-e55d-45b6-b0be-f6aaa1b76d12/content.

Cook, Megan, Nathan Critchlow, Rachel O'Donnell, and Sarah MacLean. "Alcohol's Contribution to Climate Change and Other Environmental Degradation: A Call for Research." *Health Promotion International* 39, no. 1 (2024): daae004. https://doi.org/10.1093/heapro/daae004.

Cosh, Suzanne M., Rosie Ryan, Kaii Fallander, Kylie Robinson, Josephine Tognela, Phillip J. Tully, and Amy D. Lykins. "The Relationship Between Climate Change and Mental Health: A Systematic Review of the Association

Between Eco-Anxiety, Psychological Distress, and Symptoms of Major Affective Disorders." *BMC Psychiatry* 24 (2024): 833. https://doi.org/10.1186/s12888-024-06274-1.

Crandon, Tara J., Cybele Dey, James G. Scott, Hannah J. Thomas, Suhailah Ali, and Fiona J. Charlson. "The Clinical Implications of Climate Change for Mental Health." *Nature Human Behaviour* 6, no. 11 (2022): 1474–1481. https://doi.org/10.1038/s41562-022-01477-6.

Çevre, Şehircilik ve İklim Değişikliği Bakanlığı. "Sürekli Atık Su İzleme Çalışmaları." Erişim tarihi: 8 Ekim 2026. https://lab.csb.gov.tr/surekli-atiksu-izleme-calismalari-i-5902.

Çevre, Şehircilik ve İklim Değişikliği Bakanlığı. "Türkiye'nin Hava Kalitesine Anlık Takip." 31 Ocak 2025. https://lab.csb.gov.tr/haberler/turkiyenin-hava-kalitesine-anlik-takip-290365.

D'Ascenzo, Fabrizio, Giuliana Vinci, Lucia Maddaloni, Marco Ruggeri, and Marco Savastano. "Application of Life Cycle Assessment in Beer Production: Systematic Review." *Beverages* 10, no. 3 (2024): 86. https://doi.org/10.3390/beverages10030086.

Daglioglu, Nebile, Evsen Yavuz Guzel, and Serdar Kilercioglu. "Assessment of Illicit Drugs in Wastewater and Estimation of Drugs of Abuse in Adana Province, Turkey." *Forensic Science International, 294* (2019): 132–139. https://doi.org/10.1016/j.forsciint.2018.11.012.

Daglioglu, Nebile, Asli Atasoy, Anvar Asadi, Evsen Yavuz Guzel, and Huseyin Dengiz. "Estimating Alcohol Consumption by Using Wastewater-Based Epidemiology in Adana Province, Turkey." *Environmental Science and Pollution Research, 27* (2020): 31884–31891. https://doi.org/10.1007/s11356-020-09056-w.

Daglioglu, Nebile, Evsen Yavuz Guzel, Aslı Atasoy, and İsmail Ethem Gören. "Comparison of Community Illicit Drug Use in 11 Cities of Turkey through Wastewater-Based Epidemiology." *Environmental Science and Pollution Research, 28* (2021): 15076–15089. https://doi.org/10.1007/s11356-020-11404-9.

Deloitte and Responsible Gambling Council. *Beating the Odds: The Imperative of ESG for the Future of Gambling*. August 2024. https://responsiblegambling.org/wp-content/uploads/Beating-the-Odds-The-Imperative-of-ESG-for-the-Future-of-Gambling_Aug-2024.pdf.

Deng, Yanghui, Changsheng Guo, Heng Zhang, et al. "Occurrence and Removal of Illicit Drugs in Different Wastewater Treatment Plants with Different Treatment Techniques." *Environmental Sciences Europe, 32* (2020): 28. https://doi.org/10.1186/s12302-020-00304-x.

Dimitrova, Aleksandra. "Playtime vs. Planet: The Electricity Cost and Carbon Footprint of Modern Gaming." *PlayersTime*, 2026. https://www.playerstime.com/reports/gaming-carbon-footprint/.

Ding, Lin and Chong-Miao Zhang. "Occurrence, Ecotoxicity and Ecological Risks of Psychoactive Substances in Surface Waters." *Science of the Total Environment* 926 (2024): 171788. https://doi.org/10.1016/j.scitotenv.2024.171788.

Diro, Kumela, Kenatu Angassa, Tsedekech Gebremeskel, Mikiyas Abewaa, and Ashagrie Mengistu. "Assessment of the Water Footprint of the Brewery Industry: The Case of Heineken, Addis Ababa, Ethiopia." *Results in Engineering* 24 (2024): 102928. https://doi.org/10.1016/j.rineng.2024.102928.

Dominguez-Rodriguez, A., F. Apprich, M. A. Friehs, S. van der Graaf, and J. Steinrücke. "Climate Change News and Doomscrolling: An Examination of Influencing Factors and Psychological Effects." *Acta Psychologica* 255 (2025): 104925.

Dunn, Julia A., Paul Grekin, James B. Darnton, Sean Soth, Elizabeth J. Austin, Sarah Woolworth, and E. P. Bhatraju. "Disruption of Opioid Treatment Program Services Due to an Extreme Weather Event: An Example of Climate Change Effects on the Health of Persons Who Use Drugs." *Journal of Addiction Medicine* 19, no. 3 (2025): 245–247. https://doi.org/10.1097/ADM.0000000000001403.

Eckelman, Matthew J., Kathryn Lagasse, Stefanie N. B. Sullivan, and Jonathan D. Patz. "Modeling National Health Care System Carbon Footprints: Opportunities, Challenges and Recommendations." *The Lancet Planetary Health* 6, no. 9 (2022): e760–e766. https://pmc.ncbi.nlm.nih.gov/articles/PMC9541808/.

Ekonomim. "2024'te Tütün Tüketimi Rekor Kırdı: Vergi Gelirleri ise Hedefleri Aştı." 26 Mayıs 2025. https://www.ekonomim.com/ekonomi/2024te-tutun-tuketimi-rekor-kirdi-vergi-gelirleri-ise-hedefleri-asti-haberi-820540.

Ericsson. "Mobile Network Traffic Q2 2026." *Ericsson Mobility Report*, 2026. https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/mobile-traffic-update.

Ericsson. "Short-Form Dominates Video Traffic." *Ericsson Mobility Report*, 20 November 2025. https://www.ericsson.com/en/reports-and-papers/mobility-report/articles/short-form-dominates-video-traffic.

European Commission. "Commission Preliminarily Finds the Addictive Design of Instagram and Facebook in Breach of the Digital Services Act." 10 July 2026. https://digital-strategy.ec.europa.eu/en/news/commission-preliminarily-finds-addictive-design-instagram-and-facebook-breach-digital-services-act.

European Commission. "Commission Preliminarily Finds TikTok's Addictive Design in Breach of the Digital Services Act." 6 February 2026. https://digital-strategy.ec.europa.eu/en/news/commission-preliminarily-finds-tiktoks-addictive-design-breach-digital-services-act.

European Gaming and Betting Association. Sustainability Report 2025: Creating Social Value Through Safer Play and Responsible Operations. Brüksel: European Gaming and Betting Association, 2025. https://www.egba.eu/uploads/2025/07/250709-EGBA-Annual-Sustainability-Report-2025.pdf.

European Monitoring Centre for Drugs and Drug Addiction. *Assessing Illicit Drugs in Wastewater: Advances in Wastewater-Based Drug Epidemiology*. Insights 22. Luxembourg: Publications Office of the European Union, 2016. https://doi.org/10.2810/017397.

European Union Drugs Agency. *European Drug Report 2026: Trends and Developments*. Luxembourg: Publications Office of the European Union, 2026. https://www.euda.europa.eu/publications/european-drug-report/2026_en.

European Union Drugs Agency. "Wastewater Analysis and Drugs—A European Multi-City Study." Last updated: 18 March 2026. https://www.euda.europa.eu/publications/pods/waste-water-analysis_en.

Evans, Sian E., Paul Davies, Anneke Lubben, and Barbara Kasprzyk-Hordern. "Determination of Chiral Pharmaceuticals and Illicit Drugs in Wastewater and Sludge Using Microwave Assisted Extraction, Solid-Phase Extraction and Chiral Liquid Chromatography Coupled with Tandem Mass Spectrometry." *Analytica Chimica Acta 882* (2015): 112–126. https://doi.org/10.1016/j.aca.2015.03.039.

Evci Kiraz, Emine Didem. *İklim Değişikliğinin İnsan Sağlığına Etkileri*. İklim Değişikliği Eğitim Modülleri Serisi 14. Ankara, 2019. http://profedidemevcikiraz.com/Content/uploads/docs/seri_14.pdf.

Faerron Guzmán, Carlos A., Nicole Redvers, John S. Ji, Oliver Lacey-Hall, Jemilah Mahmood, Oskar Masztalerz, Alexandra L. Phelan, Johan Rockström, and Samuel S. Myers. "Planetary Health: Focusing on the Intersection of Human Health and the Earth System." *Annual Review of Environment and Resources* 50 (2025): 303–337. https://doi.org/10.1146/annurev-environ-111523-102309.

Falfushynska, Halina, Piotr Rychter, Anastasiia Boshtova, Yuliia Faidiuk, Nadiia Kasianchuk, and Piotr Rzymski. "Illicit Drugs in Surface Waters: How to Get Fish off the Addictive Hook." *Pharmaceuticals 17*, no. 4 (2024): 537. https://doi.org/10.3390/ph17040537.

Fillaudeau, Luc, Pascal Blanpain-Avet, and Georges Daufin. "Water, Wastewater and Waste Management in Brewing Industries." *Journal of Cleaner Production* 14, no. 5 (2006): 463–471. https://doi.org/10.1016/j.jclepro.2005.01.002.

Finnish Institute for Health and Welfare. "Drugs—Population-Level Use by Region." Last updated: 3 September 2026. https://thl.fi/en/data-and-statistics/drugs/population-level-use-by-region.

Fletcher, Charlie. “Game Changers: Achieving Sustainability in the Video Game Industry.” *Earth.Org*, 9 January 2024. https://earth.org/sustainability-and-the-video-gaming-industry/.

Fuller, Richard, Philip J. Landrigan, Kalpana Balakrishnan, Glynda Bathan, Stephan Bose-O’Reilly, Michael Brauer, Jack Caravanos, Tom Chiles, Aaron Cohen, Lilian Corra, Maureen Cropper, Greg Ferraro, Jill Hanna, David Hanrahan, Howard Hu, David Hunter, Gloria Janata, Rachael Kupka, Bruce Lanphear, Maureen Lichtveld, Keith Martin, Adetoun Mustapha, Ernesto Sanchez-Triana, Karti Sandilya, Laura Schaefli, Joseph Shaw, Jessica Seddon, William Suk, Martha María Téllez-Rojo, and Chonghuai Yan. “Pollution and Health: A Progress Update.” *The Lancet Planetary Health* 6, no. 6 (2022): e535–e547. https://doi.org/10.1016/S2542-5196(22)00090-0.

GBD 2021 Risk Factors Collaborators. “Global Burden and Strength of Evidence for 88 Risk Factors in 204 Countries and 811 Subnational Locations, 1990–2021: A Systematic Analysis for the Global Burden of Disease Study 2021.” *The Lancet* 403, no. 10440 (2024): 2162–2203. https://doi.org/10.1016/S0140-6736(24)00933-4.

Gerring, Zachary F., Jackson G. Thorp, Jorien L. Treur, Karin J. H. Verweij, and Eske M. Derks. “The Genetic Landscape of Substance Use Disorders.” *Molecular Psychiatry* 29 (2024): 3694–3705. https://doi.org/10.1038/s41380-024-02547-z.

Gitnux. “Sustainability in the Alcohol Industry Statistics 2026.” 2026. https://gitnux.org/sustainability-in-the-alcohol-industry-statistics/.

Gordon, Lewis. “The Environmental Impact of a PlayStation 4.” *The Verge*, 5 December 2019. https://www.theverge.com/2019/12/5/20985330/ps4-sony-playstation-environmental-impact-carbon-footprint-manufacturing-25-anniversary.

Goren, Ismail Ethem, Asli Atasoy Aydin, Mehmet Mutlu Akinci, Evsen Yavuz Güzel, Sevcan Kilic Akinci, Semiha Selda Yildiz, and Nebile Daglioglu. “Wastewater-Based Evidence of Pregabalin Misuse in Türkiye: Implications for Drug Policy and Surveillance.” *International Journal of Drug Policy* 151 (2026): 105247. https://doi.org/10.1016/j.drugpo.2026.105247.

Green, Samantha and Meghan Davis. “Environmental Effect of Smoking Cessation.” *Canadian Family Physician* 67, no. 12 (2021): 882–883. https://doi.org/10.46747/cfp.6712882_1.

Güzel, Evsen Yavuz, Fatma Çevik, and Nebile Dağlıoğlu. “The Occurrence and Seasonal Variations of Cocaine and Its Main Metabolite Benzoylecgonine, in Seyhan River, Turkey.” *3rd Regional TIAFT Meeting in Turkey,* Nevşehir, Türkiye, 18–20 October 2018, 114–120.

Güzel, Evsen Yavuz, Aslı Atasoy, İsmail Ethem Gören, and Nebile Daglioglu. “Estimation of Alcohol and Nicotine Consumption in 11 Cities of Turkey Using Wastewater-Based Epidemiology.” *Drug Testing and Analysis, 13,* no. 4 (2021): 853–861. https://doi.org/10.1002/dta.2979.

Hallström, Elinor, Niclas Håkansson, Agneta Åkesson, Alicja Wolk, and Ulf Sonesson. “Climate Impact of Alcohol Consumption in Sweden.” *Journal of Cleaner Production* 201 (2018): 287–294. https://doi.org/10.1016/j.jclepro.2018.07.295.

Hasler, B. P., L. J. Smith, J. C. Cousins, and R. R. Bootzin. “Circadian Rhythms, Sleep, and Substance Abuse.” *Sleep Medicine Reviews* 16, no. 1 (2012): 67–81. https://doi.org/10.1016/j.smrv.2011.06.001.

Hickman, Caroline, Elizabeth Marks, Panu Pihkala, Susan Clayton, R. Eric Lewandowski, Elouise E. Mayall, Britt Wray, Catriona Mellor, and Lise van Susteren. “Climate Anxiety in Children and Young People and Their Beliefs about Government Responses to Climate Change: A Global Survey.” *The Lancet Planetary Health* 5, no. 12 (2021): e863–e873. https://doi.org/10.1016/S2542-5196(21)00278-3.

Huang, Jiaoling, Zhenxing Ge, Yijing Chu, Yuge Yan, Wei Zhang, Hong Liang, Yuqi Yang, and Hui Wang. “Associations Between Social Media Use and Anxiety and Depression Among Older Adults: Cross-Sectional Study.” *JMIR Aging* 8 (2025): e71712. https://doi.org/10.2196/71712.

Instagram, Accessed 27 August 2026, https://www.instagram.com/.

International Energy Agency. *Energy and AI*. Paris: International Energy Agency, 2025. Accessed: 12 October 2026. https://www.iea.org/reports/energy-and-ai.

International Energy Agency. *Key Questions on Energy and AI*. Paris: International Energy Agency, 2026. https://www.iea.org/reports/key-questions-on-energy-and-ai.

International Telecommunication Union and United Nations Institute for Training and Research. *The Global E-Waste Monitor 2024*. International Telecommunication Union and United Nations Institute for Training and Research, 2024. https://www.itu.int/en/ITU-D/Environment/Pages/Publications/The-Global-E-waste-Monitor-2024.aspx.

Istrate, R., V. Tulus, R. N. Grass, L. Vanbever, W. J. Stark, and G. Guillén-Gosálbez. "The Environmental Sustainability of Digital Content Consumption." *Nature Communications* 15 (2024): 3724. https://doi.org/10.1038/s41467-024-47621-w.

İklim Değişikliği Başkanlığı. *İklim Değişikliğine Uyum Stratejisi ve Eylem Planı (2024–2030)*. Ankara: T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2024. https://www.iklim.gov.tr/db/turkce/icerikler/files/iklim%20Degisikligine%20Uyum%20Stratejisi%20ve%20Eylem%20Plan.pdf.

Jhang, H., S. Kim, K. Kim, S. Choi, and S. A. Choe. "Extreme Ambient Temperature and Emergency Healthcare Service Utilization Due to Substance Use Disorders: A Systematic Review and Meta-Analysis." *Scientific Reports* 15, no. 1 (2025): 13582.

Ji, Z. and M. Jiang. "A Systematic Review of Electricity Demand for Large Language Models: Evaluations, Challenges, and Solutions." *Renewable and Sustainable Energy Reviews* 225 (2026): 116159. https://doi.org/10.1016/j.rser.2025.116159.

Jia, Y., T. Liu, and Y. Yang. "The Relationship Between Real-Life Social Support and Internet Addiction Among the Elderly in China." *Frontiers in Public Health* 10 (2022): 981307. https://doi.org/10.3389/fpubh.2022.981307.

Jin, Hangbiao, Dan Yang, Pengfei Wu, and Meirong Zhao. "Environmental Occurrence and Ecological Risks of Psychoactive Substances." *Environment International* 158 (2022): 106970. https://doi.org/10.1016/j.envint.2021.106970.

Kasprzyk-Hordern, Barbara, Frederic Béen, Lubertus Bijlsma, Werner Brack, Sara Castiglioni, Adrian Covaci, Bice S. Martincigh, Jochen F. Mueller, Alexander L. N. van Nuijs, Temilola Oluseyi, and Kevin V. Thomas. "Wastewater-Based Epidemiology for the Assessment of Population Exposure to Chemicals: The Need for Integration with Human Biomonitoring for Global One Health Actions." *Journal of Hazardous Materials* 450 (2023): 131009. https://doi.org/10.1016/j.jhazmat.2023.131009.

Keil, Mattis, Leonie Frehse, Marco Hagemeister, Mona Knieß, Oliver Lange, Tobias Kronenberg, and Wolf Rogowski. "Carbon Footprint of Healthcare Systems: A Systematic Review of Evidence and Methods." *BMJ Open* 14, no. 4 (2024): e078464. https://doi.org/10.1136/bmjopen-2023-078464.

Khan, Usman, and Jim Nicell. "Human Health Relevance of Pharmaceutically Active Compounds in Drinking Water." *The AAPS Journal 17* (2015): 558–585. https://doi.org/10.1208/s12248-015-9729-5.

Kondor, Attila Csaba, Éva Molnár, Gergely Jakab, et al. "Pharmaceuticals in Water and Sediment of Small Streams under the Pressure of Urbanization: Concentrations, Interactions, and Risks." *Science of the Total Environment, 808* (2022): 152160. https://doi.org/10.1016/j.scitotenv.2021.152160.

Koob, George F., and Jay Schulkin. "Addiction and Stress: An Allostatic View." *Neuroscience & Biobehavioral Reviews* 106 (2019): 245–262. https://doi.org/10.1016/j.neubiorev.2018.09.008.

Krishnan, R. Yedhu, S. Manikandan, R. Subbaiya, M. Biruntha, R. Balachandar, and N. Karmegam. "Origin, Transport and Ecological Risk Assessment of Illicit Drugs in the Environment—A Review." *Chemosphere* 311, chapter 2 (2023): 137091. https://doi.org/10.1016/j.chemosphere.2022.137091.

Kuloglu Genc, Merve, Selda Mercan, Murat Yayla, Tugba Tekin Bulbul, Cagdas Adioren, Sumeyye Zulal Simsek, and Faruk Asicioglu. "Monitoring Geographical Differences in Illicit Drugs, Alcohol, and Tobacco Consumption

via Wastewater-Based Epidemiology: Six Major Cities in Turkey." *Science of the Total Environment, 797* (2021): 149156. https://doi.org/10.1016/j.scitotenv.2021.149156.

Kuloglu Genc, Merve, Selda Mercan, Lubertus Bijlsma, Alberto Celma, and Faruk Asicioglu. "Uncovering the Hidden: Method Validation for Analysis of 36 Psychoactive Substances in Türkiye's Wastewater." *Journal of Chromatography A* 1760 (2025): 466304. https://doi.org/10.1016/j.chroma.2025.466304.

Küçükfarsak, Seher. "Sigara İzmaritlerinin Oluşturduğu Kirliliğin Sigara İzmariti Kirlilik İndeksi ile Değerlendirilmesi: Bir Kentsel Çevre Örneği." Yüksek lisans tezi, Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, Çevre Mühendisliği Anabilim Dalı, 2026.

Lancet Countdown. "Explore Our Data: Climate Change Impacts, Exposure and Vulnerability." 2025. https://lancetcountdown.org/explore-our-data/.

Larsen, David A., Hyatt Green, Mary B. Collins, and Brittany L. Kmush. "Wastewater Monitoring, Surveillance and Epidemiology: A Review of Terminology for a Common Understanding." *FEMS Microbes* 2 (2021): xtab011. https://doi.org/10.1093/femsmc/xtab011.

Lawrance, E. L. "Crises Impact Youth Mental Health: Climate Psychology." *Nature Climate Change* 14, no. 10 (2024): 1016–1017.

Leestma, Maddie, Thomas E. Novotny, Ronald Shadbegian, John Schneider, Juleen Lam, Nicolas Lopez-Galvez, and Rebecca J. Williams. "Tobacco Product Waste Cleanups and Costs." *Discover Environment* 3 (2025): 43. https://doi.org/10.1007/s44274-025-00234-6.

Léger-Goodes, T., C. Malboeuf-Hurtubise, T. Mastine, M. Généreux, P. O. Paradis, and C. Camden. "Eco-Anxiety in Children: A Scoping Review of the Mental Health Impacts of the Awareness of Climate Change." *Frontiers in Psychology* 13 (2022): 872544.

Lenzen, Manfred, Arunima Malik, Mengyu Li, Jacob Fry, Helga Weisz, Peter-Paul Pichler, Leonardo Suveges Moreira Chaves, Anthony Capon, and David Pencheon. "The Environmental Footprint of Health Care: A Global Assessment." *The Lancet Planetary Health* 4, no. 7 (2020): e271–e279. https://doi.org/10.1016/S2542-5196(20)30121-2.

Li, A., M. Toll, and R. Bentley. "Mapping Social Vulnerability Indicators to Understand the Health Impacts of Climate Change: A Scoping Review." *The Lancet Planetary Health* 7, no. 11 (2023): e925–e937.

Li, J. S. and G. Q. Chen. "Water Footprint Assessment for Service Sector: A Case Study of Gaming Industry in Water Scarce Macao." *Ecological Indicators* 47 (2014): 164–170. https://doi.org/10.1016/j.ecolind.2014.01.034.

Li, Zhaoxue, Xiaoyong Yu, and Kan Tian. "Algorithm-Associated Digital Addiction Among Older Adults: Mechanisms and Public Health Implications for Healthy Aging." *Frontiers in Public Health* 13 (2026): 1746304. https://doi.org/10.3389/fpubh.2025.1746304.

Limone, P., B. Ragni, and G. A. Toto. "The Epidemiology and Effects of Video Game Addiction: A Systematic Review and Meta-Analysis." *Acta Psychologica* 241 (2023): 104047. https://doi.org/10.1016/j.actpsy.2023.104047.

Lin, Chunqing, Sarah J. Cousins, Yuhui Zhu, S. E. Clingan, L. J. Mooney, Emily Kan, Fei Wu, and Yih-Ing Hser. "A Scoping Review of Social Determinants of Health's Impact on Substance Use Disorders over the Life Course." *Journal of Substance Use and Addiction Treatment* 166 (2024): 209484. https://doi.org/10.1016/j.josat.2024.209484.

MacLean, Sarah, Julia de Nicola, Kimberlea Cooper, Heather Downey, Jacqui Theobald, Lisa de Kleyn, Todd Denham, Eleanor Costello, and Lauren Rickards. "How Does Climate Change Impact People Who Use Alcohol and Other Drugs? A Scoping Review of Peer Reviewed Literature." *International Journal of Drug Policy* 134 (2024): 104649. https://doi.org/10.1016/j.drugpo.2024.104649.

Männikkö, Niko, H. Ruotsalainen, J. Miettunen, H. M. Pontes, and M. Kääriäinen. "Problematic Gaming Behaviour and Health-Related Outcomes: A Systematic Review and Meta-Analysis." *Journal of Health Psychology* 25, no. 1 (2020): 67–81. https://doi.org/10.1177/1359105317740414.

Manthey, Jakob, Syed Ahmed Hassan, Sinclair Carr, Carolin Kilian, Sören Kuitunen-Paul, and Jürgen Rehm. "What Are the Economic Costs to Society Attributable to Alcohol Use? A Systematic Review and Modelling Study." *PharmacoEconomics* 39, no. 7 (2021): 809–822. https://doi.org/10.1007/s40273-021-01031-8.

Marrucci, Luca, Tiberio Daddi, and Fabio Iraldo. "Identifying the Most Sustainable Beer Packaging through a Life Cycle Assessment." *Science of the Total Environment* 948 (2024): 174941. https://doi.org/10.1016/j.scitotenv.2024.174941.

Maya, Sigal, Ali Mirzazadeh, and James G. Kahn. "Effect of Wildfire on the Prevalence of Opioid Misuse Through Anxiety Among Young Adults in the United States: A Modeling Study." *BMC Public Health* 24 (2024): 1915. https://doi.org/10.1186/s12889-024-19417-6.

Medina, David. "Carbon Footprint of Online Multiplayer Games." *Games and Culture*. Published online 17 December 2025 8 May 2026. https://doi.org/10.1177/15554120261448902.

Melones-Peña, Natalia, Elsa C. Maroto-Melle, Susana Torrado-Del Rey, Azara Pérez-Valenciano, M. Justina Martín-Gutiérrez, and Emma Gracia-Lor. "Ecotoxicological Risk and Seasonal Removal of Licit and Illicit Drugs in Wastewater Treatment Plants: A Comparison of Secondary and Tertiary Processes." *Journal of Hazardous Materials 499* (2025): 140290. https://doi.org/10.1016/j.jhazmat.2025.140290.

Mercan, Selda, Merve Kuloglu, Tugba Tekin, Zeynep Turkmen, Ahmet Ozgur Dogru, Ayse N. Safran, Munevver Acikkol, and Faruk Asicioglu. "Wastewater-Based Monitoring of Illicit Drug Consumption in Istanbul: Preliminary Results from Two Districts." *Science of the Total Environment, 656* (2019): 231–238. https://doi.org/10.1016/j.scitotenv.2018.11.345.

Mercan, Selda, Tuğba Tekin, Merve Kuloğlu, Zeynep Türkmen, Ahmet Özgür Doğru, Ayşe Nur Safran, Münevver Açıkkol, and Faruk Aşıcıoğlu. "Comparison of Two Extraction Set-ups for the Determination of Illicit Drugs from Wastewater." *Turkiye Klinikleri Journal of Forensic Medicine and Forensic Sciences, 16*, no. 1 (2019): 28–36. https://doi.org/10.5336/forensic.2018-62466.

Mills, Evan, Norman Bourassa, Leo Rainer, Jimmy Mai, Arman Shehabi, and Nathaniel Mills. "Toward Greener Gaming: Estimating National Energy Use and Energy Efficiency Potential." *The Computer Games Journal* 8 (2019): 157–178. https://doi.org/10.1007/s40869-019-00084-2.

Milstead, Ashley E., Veronica A. H. W. Gibson, and Sadie J. Ryan. "Scaling Night-Time Artificial Light and Disease Vector Interactions into Socio-Ecological Systems: A Conceptual Assessment." *PLOS Global Public Health* 3, no. 10 (2023). https://pmc.ncbi.nlm.nih.gov/articles/PMC10613543/.

Murillo-Sandoval, Erika M., Matthew C. Hansen, Claudia M. Palacio-Castañeda, Diego Armenteras, and Nelly Rodríguez Eraso. "The End of Gunpoint Conservation: Forest Disturbance after the Colombian Peace Agreement." *Environmental Research Letters* 15, no. 10 (2020): 104033. https://doi.org/10.1088/1748-9326/abb331.

Nainani, Dhiraj, Wei Jie Ng, Stefan Wuertz, and Janelle R. Thompson. "Balancing Public Health and Group Privacy: Ethics, Rights, and Obligations for Wastewater Surveillance Systems." *Water Research* 258 (2024): 121756. https://doi.org/10.1016/j.watres.2024.121756.

New Zealand Police. "National Drugs in Wastewater Programme: Quarter 1, 2026." June 2026. https://www.police.govt.nz/about-us/publication/national-drugs-wastewater-programme-quarter-1-2026.

Palinkas, L. A. and M. Wong. "Global Climate Change and Mental Health." *Current Opinion in Psychology* 32 (2020): 12–16. https://doi.org/10.1016/j.copsyc.2019.06.023.

Parks, R. M., S. T. Rowland, V. Do, A. K. Boehme, F. Dominici, C. L. Hart, and M.-A. Kioumourtzoglou. "The Association Between Temperature and Alcohol- and Substance-Related Disorder Hospital Visits in New York State." *Communications Medicine* 3 (2023): 118. https://doi.org/10.1038/s43856-023-00346-1.

Peng, H. R. and X. F. Qin. "Digitalization as a Trigger for a Rebound Effect of Electricity Use." *Energy* 300 (2024): 131585.

Pinto da Silva, Luís and Joaquim C. G. Esteves da Silva. "Evaluation of the Carbon Footprint of the Life Cycle of Wine Production: A Review." *Cleaner and Circular Bioeconomy* 2 (2022): 100021. https://doi.org/10.1016/j.clcb.2022.100021.

Pongsiri, Montira J., Sam Bickersteth, Cristina Colón, Ruth DeFries, Mandeep Dhaliwal, Lucien Georgeson, Andrew Haines, Natalia Linou, Virginia Murray, Shahid Naeem, Roy Small, and Judit Ungvari. "Planetary Health: From Concept to Decisive Action." *The Lancet Planetary Health* 3, no. 10 (2019): e402–e404. https://doi.org/10.1016/S2542-5196(19)30190-1.

Powell, Daniel. "Narco-Deforestation: Linking Drug Policy and Forest Conservation." *Our World*, United Nations University, 6 February 2014. https://ourworld.unu.edu/en/narco-deforestation-linking-drug-policy-and-forest-conservation.

Prichard, Jeremy, Wayne Hall, Ettore Zuccato, Pim De Voogt, Nick Voulvoulis, Klaus Kummerer, Barbara Kasprzyk-Hordern, Angelo Barbato, Alberto Parabiaghi, Felix Hernandez, Janelle van Wel, Kevin V. Thomas, Karl Felt, Marie Mardal, and Sara Castiglioni. *Ethical Research Guidelines for Wastewater-Based Epidemiology and Related Fields*. Version 1.0, 2016. https://www.euda.europa.eu/drugs-library/ethical-research-guidelines-wastewater-based-epidemiology-and-related-fields_en.

Ramadan, A. M. H. and A. G. Ataallah. "Are Climate Change and Mental Health Correlated?" *General Psychiatry* 34, no. 6 (2021): e100648. https://doi.org/10.1136/gpsych-2021-100648.

Richard, Lucie, Lise Gauvin, and Kim Raine. "Ecological Models Revisited: Their Uses and Evolution in Health Promotion Over Two Decades." *Annual Review of Public Health* 32 (2011): 307–326. https://doi.org/10.1146/annurev-publhealth-031210-101141.

Rodríguez-Jiménez, Lucas, Macarena Romero-Martín, Timothy Spruell, Zoe Steley, and Juan Gómez-Salgado. "The Carbon Footprint of Healthcare Settings: A Systematic Review." *Journal of Advanced Nursing* 79, no. 8 (2023): 2830–2844. https://doi.org/10.1111/jan.15671.

Ruiz de Castañeda, Rafael, Jennifer Villers, Carlos A. Faerron Guzmán, Turan Eslanloo, Nicole de Paula, Catherine Machalaba, Jakob Zinsstag, Jürg Utzinger, Antoine Flahault, and Isabelle Bolon. "One Health and Planetary Health Research: Leveraging Differences to Grow Together." *The Lancet Planetary Health* 7, no. 2 (2023): e109–e111. https://doi.org/10.1016/S2542-5196(23)00002-5.

Saving Tool. "The Environmental Cost of Gambling: How Casinos Are Going Green." 2026. https://savingtool.co.uk/blog/the-environmental-cost-of-gambling-how-casinos-are-going-green/.

Schipper, E. L. F., T. Tanner, O. P. Dube, K. Adams, and S. Huq. "The Debate: Is Global Development Adapting to Climate Change?" *World Development Perspectives* 18 (2020): 100205. https://doi.org/10.1016/j.wdp.2020.100205.

Seltenrich, Nate. "Down to Earth: The Emerging Field of Planetary Health." *Environmental Health Perspectives* 126, no. 7 (2018): 072001. https://doi.org/10.1289/EHP2374.

Shehabi, Arman, S. Smith, A. Hubbard, A. Newkirk, N. Lei, M. A. B. Siddik, B. Holecek, J. Koomey, E. Masanet ve D. Sartor. *2024 United States Data Center Energy Usage Report*. Lawrence Berkeley National Laboratory, 2024. https://doi.org/10.71468/P1WC7Q.

Sinha, Rajita. "Stress and Substance Use Disorders: Risk, Relapse, and Treatment Outcomes." *Journal of Clinical Investigation* 134, no. 16 (2024): e172883. https://doi.org/10.1172/JCI172883.

Taşdemir, Mustafa, Abdullah Uçar, Ömer Ataç, Hüseyin Küçükali ve Samet Taşkıran. *Sağlıklı Yaşam*. 2. bs. İstanbul: Türkiye Yeşilay Cemiyeti, 2023.

Tayyab, S. and S. Jabeen. "Climate Change Induced Anxiety, Perceived Stress and Coping Strategies in Young Adults: Evidence from Pakistan." *Journal of Professional & Applied Psychology* 6, no. 4 (2025): 536–544.

ter Laak, Thomas L. and Erik Emke. *Environmental Impact of Synthetic Drug Production: Analysis of Groundwater Samples for Contaminants Derived from Illicit Synthetic Drug Production Waste*. Lisbon: European Union Drugs Agency, 2023. https://www.euda.europa.eu/drugs-library/environmental-impact-synthetic-drug-production-analysis-groundwater-samples-contaminants-derived-illicit-synthetic-drug-production-waste_en.

The Sustainable Data Center. "Why Online Gambling Giants Are Racing to Build Green Data Centers." 27 January 2026. https://www.greendatacenternews.org/data-center-design/why-online-gambling-giants-are-racing-to-build-green-data-centers/.

Tomassini, Luca, Massimo Lancia, Angela Gambelunghe, Abdellah Zahar, Niccolò Pini, and Cristiana Gambelunghe. "Exploring the Nexus of Climate Change and Substance Abuse: A Scoping Review." *International Journal of Environmental Research and Public Health* 21, no. 7 (2024): 896. https://doi.org/10.3390/ijerph21070896.

Trinh, Trong-Anh, Samuelson Appau, Sefa Awaworyi Churchill, and Lisa Farrell. "Temperature Shocks and Gambling." *Energy Economics* 115 (2022): 106406. https://doi.org/10.1016/j.eneco.2022.106406.

Trujillo-Cáceres, Silvia Juliana, Zayne M. Roa-Díaz, Catalina Paz Figueroa, Juliana Alexandra Hernández Vargas, Lyda Z. Rojas, Andrea M. Aceros Lora, Hamidreza Raeisi-Dehkordi, Sara Beigrezaei, Vicente Artola Arita, W. M. Monique Verschuren, Marilyne Menassa, and Oscar H. Franco. "Healthy Living Concepts and Definitions: A Systematic Review with Concept Analysis Proposing a Four-Dimensional Model." *Maturitas* 210 (2026): 108976. https://doi.org/10.1016/j.maturitas.2026.108976.

Türkiye Yeşilay Cemiyeti. "Okulda Bağımlılığa Müdahale Programı." *Yeşilay*. Erişim tarihi: 12 Ekim 2026. https://www.yesilay.org.tr/obm/.

Türkiye Yeşilay Cemiyeti. "Türkiye Bağımlılıkla Mücadele Eğitim Programı." *Yeşilay*. Erişim tarihi: 12 Ekim 2026. https://www.yesilay.org.tr/bagis-yap/projeler-bagis/onleme-projeleri/turkiye-bagimlilikla-mucadele-egitimprogrami/.

Türkiye Yeşilay Cemiyeti. *Türkiye Kumar Raporu. İstanbul: Türkiye Yeşilay C*emiyeti, 2025.

https://www.yesilay.org.tr/assets/uploads/pdf/turkiye-kumar-raporu-2025.pdf.

Türkiye Yeşilay Cemiyeti. "Yeşilay Yaşam Becerileri Eğitim Programı" *Yeşilay*. Erişim tarihi: 12 Ekim 2026. https://www.yesilay.org.tr/yybe/.

United Nations Children's Fund (UNICEF). *Children's Climate Risk Report 2026*. Florence: UNICEF, 2026. https://www.unicef.org/reports/childrens-climate-risk-report-2026.

United Nations Economic Commission for Europe. Guidelines for the Application of Environmental Indicators: 2023 Edition. United Nations, 2024.
https://unece.org/environment-policy/publications/guidelines-application-environmental-indicators-2023-edition.

United Nations Environment Programme (UNEP). The Growing Footprint of Digitalisation. Foresight Brief No. 27. Nairobi: UNEP, 2021.
https://wedocs.unep.org/rest/api/core/bitstreams/59e4dcd4-6483-4eca-939f-1e9575863eeb/content.

United Nations International Drug Control Programme. "Environmental Effects of Illicit Crop Cultivation." In *World Drug Report 1997*. Oxford: Oxford University Press, 1997.
https://www.unodc.org/documents/wdr/world_drug_report_1997/CH4/BOX4AB.pdf.

United Nations Office on Drugs and Crime. *Contemporary Issues on Drugs*. *World Drug Report 2025*, Booklet 2. Vienna: United Nations, 2025. Accessed: 12 October 2026.

https://www.unodc.org/unodc/en/data-and-analysis/wdr2025-contemporary-issues.html.

United Nations Office on Drugs and Crime. "The Impact of Drugs on the Environment in Europe." *World Drug Report 2025*. Vienna: United Nations, 2025. https://www.unodc.org/documents/data-and-analysis/WDR2025/WDR25_B2_Environmental_crime_draft.pdf.

United Nations Office on Drugs and Crime. World Drug Report 2022, Booklet 5: Drugs and the Environment. Vienna: United Nations Office on Drugs and Crime, 2022. https://www.unodc.org/res/wdr2022/MS/WDR22_Booklet_5.pdf.

United Nations Office on Drugs and Crime. World Drug Report 2026: Special Points of Interest. New York: United Nations, 2026. https://www.unodc.org/documents/data-and-analysis/WDR_2026/WDR26_Special_points_of_interest.pdf.

United Nations Office on Drugs and Crime and World Health Organization. *International Standards on Drug Use Prevention*. 2nd revised edition. Vienna: United Nations Office on Drugs and Crime and World Health Organization, 2018. Accessed: 12 October 2026. https://www.who.int/publications/i/item/international-standards-for-drug-use-prevention-second-edition-2018.

United States Department of Health and Human Services. *Eliminating Tobacco-Related Disease and Death: Addressing Disparities*. A Report of the Surgeon General. Washington, DC: U.S. Department of Health and Human Services, Office of the Surgeon General, 2024. https://www.hhs.gov/sites/default/files/2024-sgr-tobacco-related-health-disparities-key-findings.pdf.

United States Environmental Protection Agency. *Tribal Casino Pollution Prevention Best Management Practices/ P2 Resource List*. (Accessed: 12 October 2026) https://nepis.epa.gov/Exe/tiff2png.cgi/P10153HA.PNG?-r+75+-g+7+D%3A%5CZYFILES%5CINDEX%20DATA%5C06THRU10%5CTIFF%5C00002089%5CP10153HA.TIF.

Vangeli, Anastas, Agnieszka Małecka, Maciej Mitrşga, and Gregor Pfajfar. "From Greenwashing to Green B2B Marketing: A Systematic Literature Review." *Industrial Marketing Management* 115 (2023): 281–299. https://doi.org/10.1016/j.indmarman.2023.10.002.

Vasiliu, Octavian. "Problematic Use of Generative Artificial Intelligence Chatbots: Current Stage of Conceptual and Clinical Understanding." *Frontiers in Public Health* 14 (2026): 1816917. https://doi.org/10.3389/fpubh.2026.1816917.

Vergunst, F. and H. L. Berry. "Climate Change and Children's Mental Health: A Developmental Perspective." *Clinical Psychological Science* 10, no. 4 (2022): 767–785.

Vergunst, Francis, Helen L. Berry, Kelton Minor, and Nicholas Chadi. "Climate Change and Substance-Use Behaviors: A Risk-Pathways Framework." *Perspectives on Psychological Science* 18, no. 4 (2023): 936–954. https://doi.org/10.1177/17456916221132739.

Verma, Akshita, Samuel Sunday Ogunsola, Kaylyn A. Keith, and G. D. Thouli L. Jayawardana. "Environmental Fate of Illicit Drugs and New Psychoactive Substances in Aquatic Systems: Impact, Critical Insights, and Future Directions." *Environmental Toxicology and Pharmacology 120* (2025): 104880. https://doi.org/10.1016/j.etap.2025.104880.

Verma, Robin, Prveen, Rahul Kumar, Saurabh Tripathi, Arvind Chauhan, and Vikas Verma. "Vector-Borne Disease Risk Assessment in Hospitality Zones: A Case Study Approach." *International Journal of Mosquito Research* 12, no. 6 (2025): 51–53. https://doi.org/10.22271/23487941.2025.v12.i6a.870.

Verovšek, Taja, Ariana Šuštarič, Maria Laimou-Geraniou, Ivona Krizman-Matasić, Helena Prosen, Tina Eleršek, Vlasta Kramarič Zidar, Vesna Mislej, Boštjan Mišmaš, Marjeta Stražar, Marjetka Levstek, Bernardka Cimrmančič, Simon Lukšič, Nataša Uranjek, Tjaša Kozlovič-Bobič, Tina Kosjek, David Kocman, David Heath, and Ester Heath. "Removal of Residues of Psychoactive Substances during Wastewater Treatment, Their Occurrence in Receiving River Waters and Environmental Risk Assessment." *Science of the Total Environment* 866 (2023): 161257. https://doi.org/10.1016/j.scitotenv.2022.161257.

Volkow, Nora D. and Carlos Blanco. "Substance Use Disorders: A Comprehensive Update of Classification, Epidemiology, Neurobiology, Clinical Aspects, Treatment and Prevention." *World Psychiatry* 22, no. 2 (2023): 203–229. https://doi.org/10.1002/wps.21073.

Wardle, Heather, Louisa Degenhardt, Virve Marionneau, Gerda Reith, Charles Livingstone, Malcolm Sparrow, Lucy T. Tran, Blair Biggar, Christopher Bunn, Michael Farrell, Viktorija Kesaite, Vladimir Poznyak, Jianchao Quan, Jürgen Rehm, Angela Rintoul, Manoj Sharma, Jeremy Shiffman, Kristiana Siste, Daria Ukhova, Rachel Volberg, Joana Salifu Yendork, and Shekhar Saxena. "The Lancet Public Health Commission on Gambling." *The Lancet Public Health* 9, no. 11 (2024): e950–e994. https://doi.org/10.1016/S2468-2667(24)00167-1.

Whitmee, Sarah, Andy Haines, Chris Beyrer, Frederick Boltz, Anthony G. Capon, Braulio Ferreira de Souza Dias, Alex Ezeh, Howard Frumkin, Peng Gong, Peter Head, Richard Horton, Georgina M. Mace, Robert Marten, Samuel S. Myers, Sania Nishtar, Steven A. Osofsky, Subhrendu K. Pattanayak, Montira J. Pongsiri, Cristina Romanelli, Agnes Soucat, Jeanette Vega, and Derek Yach. "Safeguarding Human Health in the Anthropocene Epoch: Report of the Rockefeller Foundation–Lancet Commission on Planetary Health." *The Lancet* 386, no. 10007 (2015): 1973–2028. https://doi.org/10.1016/S0140-6736(15)60901-1.

WHO Framework Convention on Tobacco Control. 2025 Global Progress Report on Implementation of the WHO Framework Convention on Tobacco Control. Geneva: World Health Organization, 2025.
https://fctc.who.int/resources/publications/m/item/2025-global-progress-report-on-implementation-of-the-who-fctc.

Worku, Abebe, Nega Tefera, Helmut Kloos, and Solomon Benor. "Bioremediation of Brewery Wastewater Using Hydroponics Planted with Vetiver Grass in Addis Ababa, Ethiopia." *Bioresources and Bioprocessing* 5 (2018): 39. https://doi.org/10.1186/s40643-018-0225-5.

World Health Organization. A Global Health Strategy for 2025–2028: Advancing Equity and Resilience in a Turbulent World: Fourteenth General Programme of Work. Geneva: World Health Organization, 2025.
https://www.who.int/about/general-programme-of-work/fourteenth.

World Health Organization. "Alcohol." 28 June 2024.
https://www.who.int/news-room/fact-sheets/detail/alcohol.

World Health Organization. Clinical Descriptions and Diagnostic Requirements for ICD-11 Mental, Behavioural and Neurodevelopmental Disorders (CDDR). Geneva: World Health Organization, 2024.
https://www.who.int/publications/i/item/9789240077263.

World Health Organization. *Ethics Framework for Wastewater and Environmental Surveillance*. Geneva: World Health Organization, 2025. https://pandemichub.who.int/publications/i/item/9789240116412.

World Health Organization. Factsheet: Sustainable Development Goals (SDGs): Health Targets and Alcohol Consumption. (Accessed: 12 October 2026)
https://iris.who.int/server/api/core/bitstreams/1367a797-200e-4cc0-8914-3e9e3f8a28bd/content.

World Health Organization. "Gambling." 2 December 2024.
https://www.who.int/news-room/fact-sheets/detail/gambling.

World Health Organization. *Mapping Climate Change and Health Indicators*. Geneva: World Health Organization, 2025. https://www.who.int/publications/i/item/9789240112346.

World Health Organization. "Noncommunicable Diseases." 25 September 2025.
https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.

World Health Organization. "Q&A: World No Tobacco Day 2022." 31 March 2022. Accessed: 27 August 2026.
https://www.who.int/news-room/questions-and-answers/item/q-a-world-no-tobacco-day-2022.

World Health Organization. "Tobacco and Nicotine." 26 June 2026.
https://www.who.int/news-room/fact-sheets/detail/tobacco.

World Health Organization. “Tobacco Growing: Myth Buster.” 23 May 2023. Accessed: 27 August 2026. https://www.who.int/news-room/questions-and-answers/item/tobacco-growing--myth-buster.

World Health Organization. *Tobacco: Poisoning Our Planet*. Geneva: World Health Organization, 2022. Accessed: 12 October 2026. https://www.who.int/publications/i/item/9789240051287.

World Health Organization. *Türkiye: Health and Climate Change Country Profile 2022*. Geneva: World Health Organization, 2022. https://www.who.int/publications/i/item/WHO-HEP-ECH-CCH-22.01.05.

World Health Organization. *World No Tobacco Day 2023: Grow Food, Not Tobacco*. Geneva: World Health Organization, 2023. https://iris.who.int/items/a7c61f71-2cee-4f33-b76b-2f37cbef32f5.

World Health Organization. *World Report on Social Determinants of Health Equity*. Geneva: World Health Organization, 2025. https://www.who.int/publications/i/item/9789240107588.

World Health Organization Europe. “Second-Hand Smoke: The Invisible Killer That Continues to Cause Death and Disease.” 4 May 2023. https://www.who.int/europe/news/item/04-05-2023-secondhand-smoke-the-invisible-killer-that-continues-to-cause-death-and-disease.

World Health Organization Framework Convention on Tobacco Control. *Regulatory Options to Prevent Environmental Harm and Pollution Across the Tobacco Product Life Cycle*. Geneva: WHO FCTC Secretariat, 2025. https://iris.who.int/server/api/core/bitstreams/9139e9ae-0006-4a30-8ec0-6e01617d35f7/content.

World Health Organization Regional Office for Europe. *Environmentally Sustainable Health Systems: A Strategic Document*. Copenhagen: WHO Regional Office for Europe, 2017. Accessed: 12 October 2026.

https://www.who.int/publications/i/item/WHO-EURO-2017-2241-41996-57723.

World Health Organization Regional Office for Europe. *Tobacco Control Playbook Supplement: Tobacco Industry Harms the Environment While Misrepresenting Its Sustainability*. Copenhagen: WHO Regional Office for Europe, 2026. https://www.who.int/europe/publications/i/item/WHO-EURO-2026-3700-43459-83015.

Xiao, Tianqi, Francesco Fuso Nerini, H. Damon Matthews, Massimo Tavoni, and Fengqi You. “Environmental Impact and Net-Zero Pathways for Sustainable Artificial Intelligence Servers in the USA.” *Nature Sustainability* 8 (2025): 1541–1553. https://doi.org/10.1038/s41893-025-01681-y.

Yadav, Meena K., Michael D. Short, Cobus Gerber, Ben van den Akker, Rupak Aryal, and Christopher P. Saint. “Occurrence, Removal and Environmental Risk of Markers of Five Drugs of Abuse in Urban Wastewater Systems in South Australia.” *Environmental Science and Pollution Research 26* (2019): 33816–33826. https://doi.org/10.1007/s11356-018-2464-6.

Yang, Bo-Yi, Tianyu Zhao, Li-Xin Hu, Matthew H. E. M. Browning, Joachim Heinrich, Shyamali C. Dharmage, Bin Jalaludin, Luke D. Knibbs, Xiao-Xuan Liu, Ya-Na Luo, Peter James, Shanshan Li, Wen-Zhong Huang, Gongbo Chen, Xiao-Wen Zeng, Li-Wen Hu, Yunjiang Y, and Guang-Hui Dong. “Greenspace and Human Health: An Umbrella Review.” *The Innovation* 2, no. 4 (2021): 100164. https://doi.org/10.1016/j.xinn.2021.100164.

Yoon, Sungwon and Tai-Hing Lam. “The Illusion of Righteousness: Corporate Social Responsibility Practices of the Alcohol Industry.” *BMC Public Health* 13 (2013): 630. https://doi.org/10.1186/1471-2458-13-630.

Yu, Bolin, Yuling Pan, Jing Meng, Hao Wu, Zounachuan Sun, Congcong Du, Chenyang Shuai, Ningkang Chen, Kun Wangi, andZhenci Xu. “Assessing Sustainability Effects of Tobacco Use and Control in Global Supply Chains.” *Nature Communications* 17 (2026): 1010. Published online 17 December 2025. https://doi.org/10.1038/s41467-025-67755-9.

Yuan, G. F., H. W. Fung, M. Y. Wong, W. Shi, and X. Ding. “Longitudinal Associations Among Posttraumatic Stress Symptoms, Intolerance of Uncertainty and Internet Gaming Disorder Symptoms Among Disaster-Exposed Adolescents.” *Addictive Behaviors* 179 (2026): 108686. https://doi.org/10.1016/j.addbeh.2026.108686.

Zafeiridou, Maria, Nicholas S. Hopkinson, and Nikolaos Voulvoulis. "Cigarette Smoking: An Assessment of Tobacco's Global Environmental Footprint Across Its Entire Supply Chain." *Environmental Science & Technology* 52, no. 15 (2018): 8087–8094. https://doi.org/10.1021/acs.est.8b01533.

Zhang, Xingyu, Ningyuan Wang, Fengsu Hou, Yaseen Ali, Aaron Dora-Laskey, Chin Hwa Dahlem, and Sean Esteban McCabe. "Emergency Department Visits by Patients with Substance Use Disorder in the United States." *Western Journal of Emergency Medicine* 22, no. 5 (2021): 1076–1085. https://doi.org/10.5811/westjem.2021.3.50839.

Zhao, Jie, Jianjiang Lu, Haijun Zhao, Yujun Yan, and Hongyu Dong. "In Five Wastewater Treatment Plants in Xinjiang, China: Removal Processes for Illicit Drugs, Their Occurrence in Receiving River Waters, and Ecological Risk Assessment." *Chemosphere 339* (2023): 139668. https://doi.org/10.1016/j.chemosphere.2023.139668.

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