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JOURNAL of NATURAL and ENVIRONMENTAL STUDIES

EDITORIAL

Assist. Prof. Ahmet FİDAN

Paradoxes in Environmental Struggle

Dear Readers,

It is an undeniable fact that those engaged in environmental struggles—whether activists or professionals—often find themselves facing dilemmas and paradoxes. One of the most common challenges is that environmental choices rarely allow for simply selecting the "best" option; instead, they often require choosing the "least harmful" among several negative alternatives. In such situations, it becomes essential to conduct a thorough external analysis that considers both environmental and human factors, weighing priorities, sensitivities, and risks. A SWOT analysis is frequently among the most widely used tools in this process.

Another major paradox lies at the heart of technological development. While innovation provides us with the means to monitor environmental degradation, develop renewable energy sources, and restore damaged ecosystems, it has also historically been one of the main drivers of environmental harm. The pursuit of efficiency and convenience has often come at the cost of ecological integrity. This raises a critical question: can we truly overcome a crisis that has been partly fuelled by innovation through innovation itself? For example, while green energy, electrification, and magnetism-based energy production reduce greenhouse gas emissions, they also bring new risks such as magnetic pollution, toxic accumulation, and metabolic impacts on health. Meanwhile, the rapid advance of artificial intelligence raises concerns about the emergence of global-scale threats driven by future competition between "humans" and "robots".

A further striking paradox appears in the sphere of global cooperation. While the challenges we face—such as climate change, biodiversity loss, and transboundary pollution—demand collective action, national interests, economic priorities, and historical responsibilities frequently stand as formidable barriers to effective global environmental governance. The urgency of the environmental crisis requires unprecedented levels of collaboration, yet the road to achieving this is fraught with political and economic complexities.

Çevresel Mücadeledeki Paradokslar

Merhaba değerli okurlarımız;

Çevresel alanda mücadele veren aktivistlerin veya bu alanda profesyonel çalışanların zaman zaman ikilem ya da paradokslarla karşı karşıya kaldıkları bir gerçektir. Bu durumlardan birisi, çevresel tercihlerin yapılması gerektiğinde "en iyi'yi i seçmek yerine, mevcut olumsuz seçenekler arasında "en zararlı" olanı seçmek zorunda kalınmasıdır. Bu durumlarda çoğunlukla "çevre" ve "insan" faktörünü bir arada değerlendirerek öncelikler, hassasiyetler ve riskler bağlamında kapsamlı bir dış çevre analizi yapmak kaçınılmaz hale gelir. SWOT analizi de bu bağlamda en yaygın kullanılan yöntemlerden biridir.

Önemli bir diğer paradoks ise teknolojik gelişmelerimizin doğasında yatmaktadır. İnovasyon, çevresel bozulmayı izleme, yenilenebilir enerji kaynakları geliştirme ve kirlenmiş alanları iyileştirme imkânı sunarken, aynı zamanda, tarihsel süreçte çevresel zararın önemli bir kısmına da yol açmıştır. Verimlilik ve kolaylık arayışı, çoğu zaman ekolojik bütünlük pahasına gerçekleşmiştir. Bu noktada şu soru önem kazanmaktadır: Kısmen inovasyonun kendisi tarafından körüklenen bir krizden gerçekten de inovasyon yoluyla çıkabilir miyiz? Örneğin, yeşil enerji, elektrifikasyon ve manyetizma ile enerji üretimi, sera gazı salınımını azaltırken, bir taraftan da manyetik kirlilik, toksik madde birikimi ve metabolik etkiler gibi yeni riskler yaratmaktadır. Diğer yandan, yapay zekinin gelişimiyle birlikte, yakın gelecekte "insan" ve "robot" arasındaki rekabetin küresel ölçekte yeni tehditler doğurma ihtimali belirginleşmektedir.

Bir başka çarpıcı paradoks ise küresel iş birliği alanında ortaya çıkmaktadır. Gezegenimizin karşı karşıya olduğu iklim değişikliği, biyoçeşitlilik kaybı ve sınır ötesi kirlilik gibi sorunlar kolektif eylemi zorunlu kılarken, ulusal çıkarlar, ekonomik öncelikler ve tarihsel sorumluluklar, etkili bir küresel çevre yönetimi önünde ciddi engeller yaratmaktadır. Çevre krizinin aciliyeti, benzeri görülmemiş bir iş birliğini gerektirirken, bu hedefe ulaşmak siyasi ve ekonomik karmaşıklıklarla doludur.

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We also observe paradoxes in public perception and engagement with environmental issues. Although awareness of environmental problems has increased significantly, translating this awareness into lasting and widespread behavioural change remains a challenge. The ease of unsustainable practices, the perception that individual actions are insignificant in the face of global issues, and the constant competition between personal and societal priorities deepen the gap between knowledge and action. How we bridge this gap and cultivate a stronger sense of collective responsibility remains one of the core questions in environmental advocacy.

For developing countries like Turkey, participation in international climate justice agreements is often limited by a lack of capacity to assert strong positions. Moreover, the fact that developed nations can buy pollution rights or emission quotas from less-developed countries—forcing them to bear environmental burdens without adequate compensation—further exacerbates global justice issues. At the same time, when one nation wages extreme violence against another, the resulting helplessness in the face of the aggressor's economic power pushes small-scale activist groups into their own paradoxes. As these groups attempt to unite and strengthen their voices, powerful capital interests often find ways to undermine their solidarity or pit them against one another—another reflection of the paradoxes that define our era.

In the end, the frenzied pace of capitalist accumulation continues to ravage the world, much like a Pyrrhic victory, despite the vastness of the universe and the calm resilience of our blue planet. For this reason, one of the most important things we can do is to consistently and persistently bring the growing inevitability of global catastrophes to the forefront across scientific and social platforms. We sincerely call on you, our valued readers, to contribute to this struggle—whether in the academic or social sphere.

With our best regards.

Ayrıca, çevre sorunlarına yönelik kamuoyu algısı ve katılımında da bir paradoks gözlenmektedir. Çevre sorunlarına ilişkin farkındalık önemli ölçüde artmış olsa da bu farkındalığı kalıcı ve yaygın davranış değişikliklerine dönüştürmek bir zorlu bir süreçtir.

Sürdürülebilir olmayan uygulamaların kolaylığı, küresel sorunlar karşısında bireysel eylemlerin yetersiz olduğu algısı ve öncelikler, arasındaki rekabet, bilgi ve eylem arasındaki uçurumu derinleştirmektedir. Bu boşluğu nasıl kapatacağımız ve kolektif sorumluluk duygusunu nasıl güçlendireceğimiz, çevresel mücadelenin temel sorularından biridir.

Türkiye gibi gelişmekte olan ülkelerin iklim adaleti çerçevesinde uluslararası sözleşmelere taraf olmaları, ne yazık ki, kimi zaman gerekli karşı duruşları dirayetle gösterememesine yol açmaktadır. Dahası, gelişmiş ülkelerin kirletme haklarını geri kalmış ülkelerin kotalarından satın alarak onları kirletmeden bedel ödemeye mecbur bırakmaları, küresel ölçekte adalet sorununu derinleştirmektedir. Diğer yandan, bir ulusun başka bir ulusu tümden yok etmeye varan şiddet eylemleri ve bu bağlamda ekonomik üstünlüklerin yarattığı çaresizlik, küçük ölçekli aktivist grupları paradokslara sürüklemektedir. Bu gruplar güçlenmek için birleşmeye çalıştıkça, sermaye çevrelerinin bu birliktelikleri baltalama veya birbirine düşürme çabaları, karşılaşılan paradoksların günümüzdeki yansımalarını oluşturmaktadır.

Sonuç olarak, kapitalist birikimin azgınlığı, evrenin genişliği ve mavi gezegenimizin dinginliğine rağmen, çoğu zaman Pyrrhus zaferi misali, dünyayı kasıp kavurmaktadır. Bu nedenle, elimizden gelen en önemli şey; küresel felaketlerin ne denli kaçınılmaz hale geldiğini, bilimsel ve toplumsal tüm mecralarda düzenli ve sürekli şekilde gündeme taşımaktır. Siz değerli okurlarımızdan, akademik ya da sosyal alanlarda bu mücadeleye katkı sağlamanızı içtenlikle rica ediyoruz.

Saygılarımızla.

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Petrol Kaynaklı Deniz Kirliliğinin Önlenmesinde Uygulanan Temizleme Teknikleri ile ilgili Bir Değerlendirme

An Evaluation of Clean-up Techniques Applied in the Prevention of Oil-Sourced Marine Pollution

Fulya A. Güner [1]
Tanzer Satır [2]

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ABSTRACT
The environment is a complex and essential system that sustains human life and connects individuals to their surroundings. It encompasses the built environment, the natural environment, and all natural resources, including air, land, and water. These elements are interconnected and contribute to the overall living conditions of individuals and society. The environment is vital for human survival, and ecosystems must remain intact to ensure a healthy life. If ecosystems are damaged, life will become increasingly difficult for all living organisms, and, in extreme cases, life may cease due to pollution.
Human activities often lead to environmental pollution through the disposal of waste harmful to the environment, which can damage both living and non-living elements. Pollution may be visible to the eye or occur in an invisible form, yet its effects can still be strongly felt. Environmental pollution can manifest as biological, physical, or chemical pollution, each disrupting the ecological balance by adversely affecting ecosystems in the sea, on land, and in the air. Pollution from various sources leads to public health issues, climate change, economic costs, and negative social impacts.
Marine pollution, particularly oil spills, is one of the most severe forms of environmental pollution. Oil spills have devastating effects on marine ecosystems and have become a central focus for researchers and organizations in the field of oil spill response. This study will examine the methods used to clean oil pollution, one of the most serious types of marine pollution. It will focus on the practical application of these methods, evaluate both traditional and innovative approaches emerging from technological developments, and provide recommendations for improving oil spill response and preventing further environmental damage.

KEYWORDS: *Pollution, Marine Pollution, Types of Marine Pollution, Marine Pollution Cleaning Techniques*

ÖZ:
Çevre, insan yaşamını sürdüren ve bireyleri çevrelerine bağlayan karmaşık ve temel bir sistemdir. Yapılı çevreyi, doğal çevreyi ve hava, toprak ve su dahil olmak üzere tüm doğal kaynakları kapsar. Bu unsurlar birbiriyle bağlantılıdır ve bireylerin ve toplumun genel yaşam koşullarına katkıda bulunur. Çevre, insanların hayatta kalması için hayati önem taşır ve sağlıklı bir yaşam için ekosistemlerin bozulmadan kalması gerekir. Ekosistemler zarar görürse, tüm canlı organizmalar için yaşam giderek zorlaşır ve aşırı durumlarda kirlilik nedeniyle yaşam sona erebilir.
İnsan faaliyetleri genellikle çevreye zararlı atıkların bertaraf edilmesi yoluyla çevre kirliliğine yol açar ve bu da hem canlı hem de cansız unsurlara zarar verebilir. Kirlilik gözle görülebilir veya görünmez bir biçimde ortaya çıkabilir, ancak etkileri yine de güçlü bir şekilde hissedilebilir. Çevre kirliliği biyolojik, fiziksel veya kimyasal kirlilik olarak ortaya çıkabilir ve her biri denizdeki, karadaki ve havadaki ekosistemleri olumsuz etkileyerek ekolojik dengeyi bozar. Çeşitli kaynaklardan kaynaklanan kirlilik halk sağlığı sorunlarına, iklim değişikliğine, ekonomik maliyetlere ve olumsuz sosyal etkilere yol açmaktadır.

[1] **Corresponding Author Yetkili Yazar:** İstanbul Teknik Üniversitesi Lisansüstü Eğitim Enstitüsü, fulyaaguner@gmail.com, ORCID: 0009-0005-1103-3099
[2] İstanbul Teknik Üniversitesi Denizcilik Fakültesi, tsatir@itu.edu.tr, ORCID: 0000-0002-5308-5680

Deniz kirliliği, özellikle de petrol sızıntıları, çevre kirliliğinin en ciddi biçimlerinden biridir. Petrol sızıntılarının deniz ekosistemleri üzerinde yıkıcı etkileri vardır ve petrol sızıntılarına müdahale alanındaki araştırmacılar ve kuruluşlar için merkezi bir odak noktası haline gelmiştir. Bu çalışma, deniz kirliliğinin en ciddi türlerinden biri olan petrol kirliliğini temizlemek için kullanılan yöntemleri inceleyecektir. Bu yöntemlerin pratik uygulamalarına odaklanacak hem geleneksel hem de teknolojik gelişmelerden kaynaklanan yenilikçi yaklaşımları değerlendirecek ve petrol döküntüsü müdahalesinin iyileştirilmesi ve daha fazla çevresel zararın önlenmesi için öneriler sunacaktır.

Anahtar Kelimeler: *Kirlilik, Deniz Kirliliği, MARPOL, Deniz Kirliliği Temizleme Teknikleri*

1.GİRİŞ

İnsanlığın varoluşundan bu yana, çevreden ve çevreyi oluşturan tüm canlı ve nesnelerden yararlanmış, bu yararlanma sürecinde çevreye çeşitli atıklar bırakarak, çevre kirliliği sorunlarına neden olmuştur (Usluer vd., 2022). Bu sürecin genellikle sanayi devrim ile başladığı ve günümüze geldiğimizde de artık global anlamda tüm ülkeleri etkilediği ve sonuçlarının ekolojik krizlere neden olduğunu gözlemlemek mümkündür. Bu çevresel krizler içinde yeryüzünün yaklaşık % 70'ini oluşturan denizler, okyanuslar ve su kaynaklarının payı da oldukça önemlidir. O nedenle denizlerin kirletilmesi ve bu bağlamda tüm Dünya'da denizel kirlilik ve kıyısal ekosistem sorunları önemlidir. Bu kirlilik içinde gemilerin neden olduğu petrol sızıntıları nedeniyle büyük miktarda hasarlar meydana gelmiştir (İncaz ve Özdemir, 2018). Bu hasarların yarattığı sorunlar bağlamında denizcilik sektörü yüzlerce yıldır sayısız felaketlere maruz kalmış ve bunun sonucunda bu trajik olaylara çözüm olarak uluslararası kurallar doğmuştur. Denizlerin kirletilmesine ilişkin olarak Uluslararası Denizcilik Örgütü (IMO) tarafından uyarlanan MARPOL 73/78 (Denizlerin Gemiler Tarafından Kirletilmesinin Önlenmesine Dair Uluslararası Sözleşme), denizlerin kirletilmesinin önlenmesinde en kapsamlı uluslararası sözleşmedir. 1973 yılında IMO, artık evrensel olarak MARPOL olarak bilinen ve 1978 ve 1997 Protokolleri ile değiştirilen ve ilgili değişikliklerle güncellenen Gemilerden Kirliliğin Önlenmesine Yönelik Uluslararası Sözleşme kabul edilmiştir. MARPOL Sözleşmesi, gemilerden kaynaklanan petrol kirliliğini; toplu olarak taşınan zararlı sıvı maddeleri, paketlenmiş biçimde deniz yoluyla taşınan zararlı maddeleri; kanalizasyon, çöp ve gemilerden kaynaklanan hava kirliliğinin önlenmesini ele almaktadır. MARPOL, uluslararası deniz taşımacılığından kaynaklanan kirliliğin önemli ölçüde azaltılmasına büyük katkıda bulunmuştur ve dünya ticaret tonajının %99'una uygulanmaktadır (IMO, 29.10.2024). MARPOL sözleşmesinin amacı, deniz ortamında gemilerden kaynaklanan kirliliğin önlenmesini en aza indirmektir.

Denizlerin Ülkemizde, Gemiler Tarafından Kirletilmesinin Önlenmesine Ait Uluslararası Sözleşmesi (Convention for the Prevention of Pollution from Ships-MARPOL73/78) ve Sözleşmeyi Değiştiren 1997 Protokolünün teknik eklerine ilişkin değişikliklerin onaylanmasına, bazı andlaşmaların yapılması için Cumhurbaşkanına Yetki Verilmesi Hakkında 244 sayılı Kanunun 5'inci maddesi, MARPOL Sözleşmesini Değiştiren 1997 Protokolüne katılımımızın uygun bulunduğuna dair 6438 sayılı Kanunun 2'nci maddesi, MARPOL Sözleşmesi'nin III ve IV'üncü Eklerine Katılmamızın Uygun Bulunduğuna Dair 6477 sayılı Kanunun 2'nci maddesi ve Milletlerarası Andlaşmaların Onaylanmasına İlişkin Usul ve Esaslar Hakkında 9 sayılı Cumhurbaşkanlığı Kararnamesinin 2'nci ve 3'üncü maddeleri gereğince karar verilmiş olup Cumhurbaşkanlığının 8935 sayılı Kararı ile 06.09.2024 tarih ve 32654 Sayılı (1'inci Mükerrer) Resmî Gazetede yayımlanmıştır (İMEAK Deniz Ticaret Odası, 09.09.2024)

Dünyada denizler atıkların boşaltılabileceği bir alıcı ortam vazifesi olarak görülmüş ve yıllarca atıklarla kirletilmiş ve kirletilmeye devam edilmektedir. Genel anlamda denizlerde görülen kirliliğin kaynakları olarak direkt deşarjlar ve nehirlerle taşınma, zirai işlemler, atmosferik çökelme, deniz taşımacılığı faaliyetleri, kaçak boşaltımlar, denizdeki petrol ve gaz üretimi, deniz kazaları sıralanabilir. Bu kirlilik kaynakları tüm ülke denizlerinde kirlenmeyi yaratan temel nedenlerdir.

2.KİRLİLİK

Çevre; bütün canlı ve cansız varlıklar ve canlı varlıkların eylemlerini etkileyen ya da etkileyebilecek fiziksel, kimyasal, biyolojik ve toplumsal nitelikteki tüm etkenlerdir (Eroğlu, 2018).

İnsanlar gerçekleştirdikleri eylemlerin sonucunda doğa ve çevre için zararlı bir çeşit atıklar ortaya çıkarırlar. Bu atıklar plastikler gibi katı madde, kimyasallar gibi sıvı ya da zehirli gazlar gibi çok çeşitli şekillerde olabilir. Ortaya çıkan bütün bu atıkların doğaya karışarak, içerisinde yaşayan canlı ve cansız bütün varlıklara zarar vermesi kirlilik olarak isimlendirilir. Bu kirlilik bazen gözle görülebilecek boyutlarda olurken, bazen ise gözle görülmeyen ama etkisi hissedilebilen şekilde de meydana gelebilir (Enez Kaymakamlığı, 2021).
Gelişmiş ülkeler küresel çevre sorunları ile mücadele ederken, gelişmemiş ve gelişmekte olan ülkeler kendi başlarına ciddi ve hızla büyüyen kirlilik sorunları ile mücadele ediyor (JICA, 27.10. 2024)
Çevre kirliliği, kirleticilerin özelliğine ve etkide bulundukları ortama göre çeşitli türlere ayrılabilir. Çevre kirliliğinin başta deniz kirliliği olmak üzere ek olarak bazı önemli türleri şu şekildedir: Hava kirliliği, ses kirliliği, ışık kirliliği, toprak kirliliği, su kirliliği, yeraltı suları kirliliği, yerüstü suları kirliliği, akarsu kirliliği, göl kirliliği (Kuleyin, 2024). Çevre kirliliğinin halk sağlığının bozulması, çevresel bozulmalar, iklim değişikliği, ekonomik maliyetler, olumsuz sosyal etkiler gibi etkileri vardır (Nextias, 15.11.2023).

3. DENİZ KİRLİLİĞİ

3.1. Deniz Kirliliği Tanımı

Deniz kirliliği, 'insan tarafından doğrudan veya dolaylı olarak deniz ortamına madde veya enerji sokulması sonucu insan sağlığına tehlike, balıkçılık da dahil olmak üzere deniz faaliyetlerinin engellenmesi, deniz suyunun kullanım kalitesinin bozulması ve olanaklarda azalma gibi zararlı etkilere yol açması' olarak tanımlanmıştır (GESAMP, 1991).

3.2. Denizlerde Kirliliğe Neden Olan Kirletici Kaynaklar

Denizlerde kirliliğe neden olan kirletici kaynaklar çeşitli şekillerde sınıflandırılabilir. İnsanlığın etkinlikleri de dikkate alınarak, üç farklı başlık altında incelemek mümkündür (İncaz vd, 2000).

Denizlerin hava yoluyla kirletilmesi

-Hava kirliliği mevcut olan bölgelerdeki yağışlar ve kimyasal olaylar sonucu atmosferik çevrimdeki kirliliğin yağışlar yoluyla denizlere ulaşması
- Denizin hava yoluyla kirletilmesinin bir başka sebebi de sanayiler veya konutlar yoluyla oluşturulan hava kirliliğidir.
- Hava taşıtlarından kaynaklanan kirlilik

Denizlerin kara yoluyla kirletilmesi

- Domestik atıklardan çöpler, pis sular ve lağım suları
- Sanayinin katı, sıvı atıklarından
- Zirai etkinlikler sebebiyle kirlenme
- Enerji üretim merkezlerinden
- Turizm faaliyetleri ve kıyıların dağınık faaliyet vermesi nedeniyle olan
- Akarsu ve derelerin taşıdığı karadan kaynaklı atıklardan denizlerin kirlenmesi

Denizlerin denizlerdeki faaliyetler ve oluşumlar yoluyla kirletilmesi

- Deniz yolu taşımacılığı faaliyetleri ve atıklarından oluşan kirlilik
- Yükleme tahliye operasyonları ya da temizlik işlemleri esnasında meydana gelen kirlilik
- Gemilerin kendi yakıt operasyonları esnasında meydana gelen kirlilik
- Gemilerin kirli sular ve lağım sularının denize boşaltılmasından oluşan kirlilik
- Gemi sintine ve pis sularından oluşan kirlilik
- Gemilerden katı ya da katımsı atıkların denize tahliyesi veya atılmasından oluşan kirlilik
- Spesifik olarak tanker gemilerinin gasfree operasyonlarından dolayı meydana gelen kirlilik

- Gemilerin kanuni veya kanuni olmayan şekilde yük olarak taşıdıkları tehlikeli maddelerin veya tehlikeli atıkların denize tahliyesi veya dökülmesinden dolayı meydana gelen kirlilik
- Deniz kazası nedeniyle oluşan kirlilik
- Deniz dibi kaynaklarından üretilen petrolden oluşan kirlilik
-Su ürünleri üretilmesi ve avlanması sebebiyle meydana gelen kirlilik
-Deniz dibi araştırmaları ve kazıları sebebiyle meydana gelen kirlilik
- Askeri faaliyetler ve harp neticesinde meydana gelen deniz dibi araştırmaları ve kazıları sebebiyle meydana gelen kirlilikler

Denizlere karışan kirleticilerin çoğu, kıyı şeritleri boyunca ve iç kesimlerde gerçekleşen insan faaliyetlerinden kaynaklanır. Kirliliğin en büyük kaynaklarından biri, akış sonucu oluşan noktasal olmayan kaynak kirliliğidir. Noktasal olmayan kaynak kirliliği, septik tanklar, araçlar, çiftlikler, hayvan çiftlikleri ve kereste hasat alanları gibi birçok kaynaktan gelebilir. Petrol veya kimyasal sızıntı gibi tek bir kaynaktan gelen kirliliğe noktasal kaynak kirliliği denir. Noktasal kaynak kirliliği olayları genellikle büyük etkilere sahiptir, ancak neyse ki daha az sıklıkta meydana gelirler. Arızalı veya hasarlı fabrikalardan veya su arıtma sistemlerinden gelen deşarjlar da noktasal kaynak kirliliği olarak kabul edilir. (National Oceanic and Atmospheric Administration, 2024)

3.3.Deniz Kirliliğinin Türleri

3.3.1. Plastik ve Çöp Kirliliği

Plastik şişeler, torbalar, sigara izmaritleri, plastik parçalar, pipetler, lastikler, ağlar vb. balıklar ve diğer canlıların bunlara dolanması, boğulması ve ölmesi nedeniyle deniz ekosistemini tehdit eder. Kaplumbağalar ve deniz kuşları bazen bunları yiyecekle karıştırabilir ve hatta sindirebilir, bu da sindirim sistemlerinde bir yırtılmaya ve sonunda açlıktan ölmelerine neden olabilir (Ahmed, 2022). Her yıl nehirlerden okyanusa 1,15 ila 2,41 milyon ton plastik atığın girdiğini ve emisyonların %74'ünden fazlasının Mayıs ile Ekim ayları arasında meydana geldiğini tahmin edilmektedir. Çoğunluğu Asya'da bulunan 20 kirletici nehir, küresel toplamın %67'sini oluşturmaktadır (Lebreton, 2017).

3.3.2. Gübre, Pestisit ve Böcek Öldürücülerden Kaynaklanan Kirlilik

Dünyada her yıl 4.000.000 tondan fazla pestisit kullanılmakta ve dünya çapındaki su kütlelerinde eşik değerlerinin üzerinde yüksek konsantrasyonlar tespit edilmiştir. Oluşan atık su (pestisitlerle kirlenmiş) insan sağlığı, ekosistem ve su ortamı üzerinde olumsuz etkilere sahiptir (Rad ve diğerleri, 2022). Besin açısından zengin gübreler, pestisitler, böcek ilaçları ve herbisitler çiftliklere püskürtülür ve fazlası genellikle yakınlardaki akarsulara, nehirlere, koylara ve haliçlere gider ve bunlar da onları okyanusa taşır (Ahmed, 2022). Pestisit kirliliği, insan sağlığı ve su ekosistemleri için ortaya çıkan küresel bir tehdittir. Pestisitler su canlılarının besin zincirinin bozulmasına ve popülasyonlarının azalmasına neden olmaktadır (AbuQamar ve diğerleri, 2024).

3.3.3. Gemiler ve Denizcilik Ekipmanları Tarafından Yapılan Gürültüden Kaynaklanan Kirlilik

Deniz kirliliği yalnızca elle tutulur plastik veya diğer kirleticiler değil, gürültü kirliliği gibi elle tutulamayan diğer unsurları da içerir. Balinalar ve yunuslar gibi birçok deniz memelisinin keskin bir görüşü yoktur. Çevrelerini anlarlar ve sesler kullanarak türleriyle uzun mesafelerden iletişim kurarlar. Buna eko lokasyon denir (Usluer, 2024). Ancak gemilerden, sonarlardan ve diğer ekipmanlardan gelen yapay sesler iletişimlerini bozar. Yaşam döngülerini bozabilir ve göç, üreme düzenleri ve avlanma süreçlerini etkileyebilir. Seslere karşı hassas oldukları için aşırı gürültü sağlıklarına zarar verebilir. Gürültünün yanı sıra, bu güzel memeliler geminin gövdeleri ve pervaneleri tarafından yaralanır ve ölümcül yaralanmalar alırlar (Ahmed, 2022). Gemilerdeki sürekli gürültü insan sağlığı üzerinde olumsuz etki yaratabilir. IMO, 2012 yılında, Denizde Can Güvenliği Uluslararası Sözleşmesi'nde (SOLAS) gemilerin gemideki gürültüyü azaltacak ve personeli gürültüden koruyacak şekilde inşa edilmesini ve gemilerdeki gürültü seviyelerine ilişkin Kod'a uygun olmasını gerektiren bir düzenleme kabul etti. Kod, makine daireleri, kontrol odaları, atölyeler, konaklama ve gemilerdeki diğer

alanlar için zorunlu maksimum gürültü seviyesi sınırlarını belirler. Uluslararası Çalışma Örgütü'nün Deniz Çalışma Sözleşmesi (MLC 2006) de gemilerde tehlikeli düzeydeki gürültüye maruz kalma riskinin önlenmesine ilişkin gereklilikler içermektedir (International Maritime Organization, 11.10.2024).

3.3.4. Güneş Kremleri Benzeri Cilt Bakım Ürünlerindeki Kimyasalların Yarattığı Kirlilik

Araştırmalar, güneş kremlerinde ve diğer kişisel sağlık ürünlerinde bulunan bazı kimyasalların mercan resiflerinin sağlığını da tehdit ettiğini gösteriyor. Güneş kremleri ve cildimizi güneşin zararlı ultraviyole ışınlarından koruyan çeşitli topikal ürünler mercanlar ve diğer deniz canlıları için ölümcüldür (Ahmed, 2022). Güneş kremleri mercanlar üzerinde beyazlamaya neden olabilir ve bu da sonunda ölümlerine yol açabilir (Chatzigianni ve diğerleri, 2022). Yapılan araştırmalarda yayınlanan araştırma, erken gelişen mercanlarda dört önemli toksik etki olduğunu gösterdi: beyazlamaya karşı artan duyarlılık; DNA hasarı (genotoksisite); anormal iskelet gelişimi (endokrin bozulması yoluyla); ve bebek mercanlarda büyük deformiteler (Downs, diğerleri, 2016).

3.3.5. Petrol Sızıntılarından Kaynaklanan Kirlilik

Tankerler ham petrolü denizde taşırken petrol sızıntıları meydana gelebilir. Ancak, onları son derece tehlikeli yapan şey, onları temizlemenin zorluğu ve deniz ekosistemi üzerindeki etkileridir. Petrol, su yüzeyinde ince bir tabaka oluşturarak sudaki oksijenin çözünmesini engeller. Kıyı bölgelerinde, plajları kirletebilir ve deniz kuşlarını öldürebilir. Petrol bir kuşun kanatlarına bulandığında uçamaz ve tüyleri yalıtım özelliklerini kaybeder, bunun sonucunda hipotermi nedeniyle ölüm meydana gelir (Ahmed, 2022).

3.3.6. Zehirli Endüstriyel Atıklardan Kaynaklanan Kirlilik

Endüstriyel atık su, endüstriyel proseslerden kaynaklanan kullanılmış veya kirlenmiş suyu ifade eder. İnsanlar, yaban hayatı ve daha geniş çevre için zararlı olabilecek çeşitli kirleticiler içerir. Endüstriyel atık su, ekosistemlerin sağlığını tehdit eden ve uzun vadeli ekolojik değişimlere yol açan büyük bir küresel çevre sorunudur. Bu etkiler, biyolojik çeşitliliğin kaybından, toprağın bozulmasından ve su yaşamına yönelik tehlikelerden, küresel olarak ölümcül mikro kirleticilerin birikmesine kadar uzanır (Fahrion, 12.03. 2024).

3.3.7. Pis Sulardan Kaynaklanan Kirlilik

Pis sular çevreye salındığında veya sızdığında önemli hava, toprak ve su kirliliğine neden olurlar. Çoğu zaman, arıtılmamış pis su, altyapı veya düzenleme eksikliği nedeniyle yanlış bir şekilde su kütlelerine geri salınır. Bu olduğunda, göller, nehirler ve denizler ve diğer tüm kıyı suları önemli ölçüde kirlenebilir (Peacock, 13.07. 2022). Bu tür sular ayrıca su ekosistemlerini ve o suyu içen insanların sağlığını olumsuz yönde etkileyen metaller veya kimyasallar içerebilir. Toksinler deniz yaşamını öldürebilir ve besin zincirini bozabilir (Ahmed, 2022).

3.3.8. Işık Kirliliği

Kıyı şehirleri, açık deniz petrol platformları ve gemiler okyanusu yapay ışıkla doldurarak çok çeşitli deniz canlılarını etkiliyor. En küçük zooplanktonlardan en büyük balinalara kadar, ışık kirliliği doğal ritimleri bozarak deniz habitatlarını tehdit ediyor.

Gezegenimizdeki tüm hayvanlar arasında, belki de hiçbiri deniz kaplumbağaları kadar ışık kirliliğinden tehdit altında değildir. Kıyı şehirlerinden gelen gece yapay ışığı, yuvalama alanlarının başarısını büyük ölçüde etkiler. Sonuç olarak, yetişkin dişi deniz kaplumbağaları yumurtalarını bırakmak için uygun karanlık bir plaj bulmakta zorlanırlar ve şehirlerimizin ışıkları yavrularını şaşırtır. Doğal bir plajda, yeni yumurtadan çıkan deniz kaplumbağaları açık ufku bulur ve suya doğru yönelir. Ne yazık ki, ışık kirliliği yavruları okyanustan uzaklaştırır ve burada yorgunluktan veya yırtıcılardan ölürler (Chortos, 08.06.2024).

3.3.9. Atmosferik Emisyonlardan Kaynaklanan Kirlilik

Okyanus atmosfer nedeniyle çeşitli şekillerde kirlenebilir. Rüzgâr, küçük parçacıklar, plastik parçaları vb. dahil olmak üzere toz ve döküntüleri çöplüklerden nehirlere veya denizlere taşır. Yaz aylarında, Sahra Çölü'nden gelen toz Karayipler ve Florida'ya taşınır ve buradan subtropikal Atlantik'e akar. Bu toz olayları Karayipler ve Florida boyunca mercan resiflerinin sağlığını bozmuştur. Okyanusların ve denizlerin pH'ını etkiler, bu da daha asidik hale gelerek okyanus asitlenmesine yol açar. Sonuç olarak, mercanlar ve planktonlar gibi deniz canlıları, kabuklarını ve iskeletlerini bu tür asidik suda oluşturamadıkları için etkilenirler, bu da kabuklarını veya iskeletlerini aşındırır (Ahmed, 2022).

3.3.10. Ötrofikasyondan Kaynaklanan Okyanus Kirliliği

Ötrofikasyon, bir su kütlesinin, esas olarak azot ve fosfor olmak üzere, yosun büyümesine yol açan aşırı besinleri aldığında meydana gelen bir süreçtir. Tatlı su kaynaklarından gelen besinler, belediye ve endüstriyel tesislerden gelen akış yoluyla açık denizlere ve okyanuslara ulaşır. Sonuçları, tüm güneş ışığını emen ve su yüzeyine nüfuz etmesini engelleyen zararlı alg patlamalarıdır, bu da okyanusta oksijen seviyelerinin yetersiz olduğu ölü bölgeler yaratır. Ayrıca, bazı deniz memelileri ölürken diğerleri bu alanlardan diğerlerine göç eder ve deniz ekosisteminin hassas dengesini etkiler (Ahmed, 2022).

3.3.11. Derin Deniz Madenciliğinden Kaynaklanan Okyanus Kirliliği

Derin deniz madenciliği, 200 metreden daha derinlerdeki okyanus tabanından metal ve mineralleri çıkarma uygulamasıdır. İşletme için hedeflenen cevher türüne göre tanımlanan farklı derin deniz madenciliği türleri vardır (IUCN, 01.03.2024). Derin denizin bir zamanlar yaşamdan yoksun olduğu düşünülürken artık gezegendeki en büyük yaşanabilir alan olduğunu ve göz kamaştırıcı bir yaşam çeşitliliğine ev sahipliği yaptığını biliyoruz. Bugüne kadar derin okyanusta on binlerce tür bulundu ve milyonlarca daha olabileceği tahmin ediliyor. Deniz yaşamına doğrudan zarar: Daha az hareketli derin deniz organizmalarının deniz tabanına yerleştirilen ağır madencilik ekipmanlarıyla doğrudan temas yoluyla ölmesi ve organizmaların bu makinelerin yaratması muhtemel tortu tüyleri tarafından boğulup nefessiz kalması olasılığı yüksektir. Sıcak madencilik atık suyu da aşırı ısınma ve zehirlenme yoluyla deniz yaşamını öldürebilir. Madencilik faaliyetleri, doğal olarak karanlık ve sessiz bir ortamda yoğun gürültü ve ışık kirliliği yaratarak derin deniz türlerinin beslenmesini ve üremesini bozabilir (Ashford, ve diğerleri, 23.02.2024). Derin deniz madenciliği operasyonlarının okyanuslar üzerinde zararlı etkileri vardır. 30 yıllık bir madencilik projesi yaklaşık dokuz bin kilometrekarelik okyanus tabanını etkiler. Denizaltı dağları kobalt ve diğer metalleri barındıran dış kabuk tabakasından sıyrıldığında, derin deniz süngerleri ve mercan ekosistemleri yok olur (Ahmed, 2022).

3.3.12. Tarama İşleminin Deniz Ortamında Yarattığı Kirlilik

Tarama faaliyeti, tüm su yollarında istenmeyen tortuları temizlemek için gerçekleştirilmesi gereken bir faaliyettir. Ancak bu faaliyet deniz trafiğinin düzenliliğini sağlasa da deniz ortamı için tehditleri oldukça fazladır. Bu nedenle tarama makinelerinin oldukça dikkatli bir şekilde gerçekleştirilmesi gerekir. Tarama işleminin ana odağı, altında kalan tortuları çıkarmak olduğundan, sürecin çevresel etkileri ortaya çıkabilmekte deniz çevresine zarar verebilmektedir. Herhangi bir su kütlesindeki toprak birikintileri belirli bir önceden belirlenmiş bileşime sahiptir. Tarama yoluyla bu bileşim değiştirilebilir. Söz konusu değişiklik nedeniyle, toprağın orijinal bileşimine bağlı olan canlıların ve organizmaların mevcut yaşam alanı, meydana gelen olumsuz deniz çevresi değişikliklerin nedeniyle yok olmaktadır. Sualtı toprak bileşimindeki bu değişiklik nedeniyle, su altındaki toprağın bulanıklığı da değişir. Bu, durum yeni ve zararlı organizmaların yaratılması, istenmeyen organizmaların su kütlesindeki diğer bölgelere aktarılması ve ekstra ve istenmeyen besinlerin salınması yoluyla daha geniş bir kirlenme ve organik süreçlerin yayılmasına yol açarak sorunlara yol açar. Bulanıklık ayrıca, halihazırda var olan kirlenmelerin su kütlesine daha fazla yayılmasına neden olur ve bu da deniz ortamını olumsuz etkiler (Karan, 26.07.2021).

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4. DENİZDE PETROL SIZINTISI TEMİZLEME YÖNTEMLERİ

Petrol ve petrol türevi yakıtların küresel kullanımı arttığından, bu ürünlerin çevreye akut ve kronik salınım olasılığı da artmıştır. Buna ek olarak, ekonomik faaliyetlerin artmasıyla birlikte gemicilik faaliyetleri ve liman ihtiyaçları da artmakta, bu da petrol tüketimi ve petrol sızıntısı miktarı üzerinde etkili olmaktadır. Çok sayıda petrol tankeri, zorlu denizcilik koşulları ve yüksek yoğunluklu bölgelerin bir araya gelmesiyle karakterize edilen dünya çapındaki deniz seyrüseferlerini kullanmaktadır (Ateş Duru ve İncaz, 2008).

Ham petrol herhangi bir yolla denize döküldüğünde, sudan daha düşük yoğunluğu nedeniyle hızla dökülen petrol su yüzeyine yükselir. Normalde petrolün yeryüzünün derinliklerinden çıkarılması sürecinde büyük ölçekli sorunlar görülmez. Ancak, bir petrol sızıntısı olduğunda bu durum felakete yol açabilir (Ateş Duru ve İncaz, 2008). Su yüzeyine yükselen petrol deniz yüzeyinde birkaç milimetre kalınlığında bir tabaka oluşturur. Bu sırada petrol sızıntısından çoğu toksik bileşen de dahil olmak üzere uçucu bileşenler, hızla buharlaşarak atmosfere yayılır. Doğanın çevrim doğal çevrimi içinde rüzgarlar ve oluşan akıntılar ile önce yakın kıyılara daha sonra daha uzak kıyılara doğru doğru taşınmasına neden olur. Azwell'e göre; her yıl üç milyon ton petrol kirleticisi okyanusa sızmaktadır. Buna ek olarak Azwell tarafından büyük petrol sızıntılarından biri olan Deepwater Horizon patlamasında ortaya çıkan petrol sızıntısı ile kurtarma ve iyileştirme teknolojilerinin petrol sondajının büyüklüğüne ayak uyduramadığı ifade edilmiştir. O nedenle deniz kirliliğinde eski teknolojiler yanında yeni teknolojilere de ihtiyaç duyulmaktadır (Thomas, 2013). En büyük deniz petrol sızıntısı olan Deepwater Horizon felaketi, Nisan 2010'da bir petrol platformunun patlamasının ardından yaklaşık 800 milyon litre ham petrolün Meksika Körfezi'ne akmasına neden oldu. Çevre üzerindeki etkisi özellikle balıklar, kuşlar ve deniz hayvanlarının büyük miktarlarda ölüm ile ortaya çıktı.

Şekil 1. Deepwater Horizon Patlaması Sonrası Çalışmalar (Prueitt, 19.04.2018).

Denizde petrol kirliliğini temizleme yöntemlerini temel olarak dört grupta incelemek mümkündür. Güncel teknolojik değişmelerle bu sınıflandırmalar değişiklik gösterebilmektedir. Bu temel yöntemler; mekanik yöntemler, kimyasal yöntemler, yerinde yakma yöntemi ve biyolojik yöntemlerdir.

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4.1. Mekanik Yöntemler

Petrol sızıntısını temizlemenin en iyi yöntemi mekanik yöntemdir. Bunun nedeni mekanik yöntemin petrolü deniz ortamından tamamen uzaklaştırmasıdır. Ancak bu yöntem sadece deniz sakin olduğunda uygulanabilir. Mekanik yöntemlerin yüksek deniz dalgaları, yüksek rüzgar hızı gibi durumlarda uygulanması zordur (Obi ve diğerleri, 2014). Mekanik yöntemler, özelliklerini değiştirmeden su yüzeyinde kalan petrolü tutmak ve geri kazanmak için kullanılır. Bunlar arasında bomlar, sıyırıcılar ve emici malzemeler bulunmaktadır (Ventikos vd. 2004). Ancak, rüzgâr dalgaları ve akıntılardan etkilenir. Mekanik yöntemler içinde boomlar, skimmerler ve sorbentler bulunur.

Boomlar: Bu yöntem petrol sızıntılarını kontrol etmenin en basit ve en yaygın temizleme yöntemidir; dökülme alanını izole etmek için suya doğru uzanan büyük yüzen boomların kullanılmasını içerir (Stellarix, 21.03.2024) Boomlar, yüzen petrolü tek bir yerde tutmaya yardımcı olan yüzer bariyerlerdir. Bomlar yalnızca kıyıdan temizleme yapan sistemler gibi daha sakin sularda daha iyi çalışabilirler (Collins, 14.07.2024). Petrol sızıntısının etrafa yayılmasını engellemek için sızıntının etrafı çevrelenir. Bu yöntem yalnızca petrol tek bir noktada olduğunda etkilidir ve olayın meydana gelmesinden kısa bir süre içinde müdahale edileceği zaman işe yarar aksi takdirde sızıntı denizde dağılacağı için bu yöntemi kullanmak faydalı ve elverişli olmayacaktır (Agarwal, 30.04.2021).

Şekil 2. Skimmer (Mavi Deniz, 2024)

Skimmer’lar: Bu makineler su yüzeyinden petrolü sıyırır. Önce petrolü yoğunlaştırır ve daha sonra etkili bir şekilde sıyırır (Stellarix, 21.03.2024). Petrol, petrol boomları kullanılarak çevrelendikten sonra, kirleticileri su yüzeyinden çıkarmak için gemilere skimmer'lar veya petrol kepçeleri yerleştirilebilir. Bu tekniğin önündeki en büyük engel, döküntülerin varlığıdır; çünkü skimmer'lar kolayca tıkanabilir (Agarwal, 30.04.2021). Skimmer’lar dökülen petrolün geri kazanılması için ekonomik olarak uygun olmaya devam etmekte ve bu da onları temizleme operasyonlarının temel taşı haline getirmektedir (Fatima, 13.02.2024).

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Şekil 3. Sorbentler. (Ypers, 25 02.2020)

Sorbentler: Sorbentler, emilim ve/veya yüzeyde bir tabaka oluşturma mekanizmasıyla petrolü geri kazanırlar (Stellarix, 21.03.2024). Emiciler, petrolün yapıldıkları malzemedeki gözenek boşluklarına nüfuz etmesine izin verirken, adsorbanlar petrolü yüzeylerine çeker ancak malzemeye nüfuz etmesine izin vermez. sorbentler çoğunlukla son yağ izlerini gidermek için veya yağın temizlenemeyeceği alanlarda kullanılır. (U.S. Environmental Protection Agency, 2024). Petrolün geri kazanılması mümkün olduğundan israfın ve kirliliğin önüne geçiliyor. Emilimden sonra, sorbent maddeler etkili bir şekilde geri alınmalıdır. Küçük sızıntılarda veya büyük sızıntıların bıraktığı izlerin giderilmesinde en etkili yöntemdir (Agarwal, 30.04.2021).

4.2. Kimyasal Yöntemler

Dağıtıcılar (Dispersantlar): Denize atılan boomlar kullanılarak sızıntı kontrol altına alınamadığı durumlarda dağıtıcılar deterjan benzeri bir etkiye sahiptir; bir petrol sızıntısını çok küçük damlacıklara böler ve bunlar suda seyrelir. Bu daha küçük petrol parçacıkları daha kolay biyolojik olarak parçalanır ve böylece yüzey sızıntısı tarafından tehdit edilen hassas yaşam alanlarını korur. Dikkat çekici bir şekilde, dağıtıcılar dökülen petrolü temizlemez (Stellarix, 21.03.2024). Geniş alanlara yayılan dökülmelerde etkili bir şekilde kullanılabilir. Dağıtıcıların toksisitesi deniz canlılarını, özellikle mercan ve deniz çayırı gibi hareketsiz canlıları etkileyebilir (Agarwal, 30.04.2021). Katılaştırıcılar (Solidifiers): Bunlar petrolle fiziksel bir bağ oluşturur ve petrolün viskozitesini, petrolün kauçuk benzeri bir katıya katılaştığı noktaya kadar yükseltir (Stellarix, 21.03.2024).

4.3. Termal veya Yerinde Yakma Yöntemi

Yerinde yakma, petrol döküntüsü müdahale ekipleri tarafından kullanılan ve bir petrol kaynağından dökülen petrolün kontrollü olarak yakılmasını içeren bir tekniktir (Walther, 2014).

Bu yöntem, petrol sızıntılarının neredeyse %98'ini gidermeye yardımcı olur. Bu yöntem diğer yöntemlerden daha faydalıdır ancak, yanan kalıntılar ve ilişkili dumanlar, sızıntı alanının yakınındaki hava kalitesini etkiler (Stellarix, 21.03.2024). Yerinde yakma yönteminin ölçülebilir etkinliği için su yüzeyindeki petrolün minimum kalınlığı 3 mm'dir. Bunun nedeni, yeterince kalın olmayan bir tabakayı tutuşturmanın zor ve hatta neredeyse imkânsız olmasıdır. Petrol daha geniş bir alana yayılmadan ve kalınlığı azalmadan önce, kullanıldığında işe yarıyor (Agarwal, 30.04.2021).

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Şekil 4. Yerinde Yakma (International Association of Oil & Gas Producers, 2016)

4.4. Biolojk Yöntemler

Bakteriler gibi belirli mikroorganizmalar dökülen petrolle beslenir. Yöntem oldukça uygun maliyetli ve sürdürülebilirdir ve çok fazla insan gücü gerektirmez. Ancak, çok zaman alıcıdır. Özellikle kıyı şeridine yakın alanlar için uygundur (Stellarix, 21.03.2024). Azot ve fosfor gibi besin maddeleri ekleyerek doğal biyolojik bozunma sürecini hızlandırabiliriz. Bu besinler ilgili mikroorganizmaların büyümesini teşvik eder (Obi ve diğerleri, 2014). Azot ve fosfor bakımından zengin maddeler, 1989 yılında Alaska'da meydana gelen Exxon Valdez petrol döküntüsünde mikrobiyal faaliyetleri arttırmak için katalizör olarak kullanılmıştır (Adofo ve diğerleri, 2022).

5. SONUÇ VE ÖNERİLER

Deniz kirliliğini azaltmak, tüm ülkeler ve endüstrilerin ele alınması gereken küresel bir zorunluluktur. Çünkü deniz kirliliği küresel bir sorundur. Denizlerde oluşan kirlilik birden fazla kaynaktan oluşur ve ülke sınırları aşar. Deniz kirliliği deniz ekosistemlerini tehlikeye atar. Atmosferik oksijen üretimini engeller. İnsan sağlığına yönelik tehditleri de oldukça büyüktür ve süreçte artmaktadır, ancak deniz kirliliğinin önlenmesi için gerekli çabaların önemi hala tam olarak anlaşılmamıştır. Deniz kirliliğinin ortaya koyduğu ekonomik maliyetlerin de henüz tam olarak hesaplanmadığını ifade edebiliriz. Tüm kirlilik biçimleri gibi deniz kirliliği de öncelikli kirlilik kaynaklarını hedef alan yasa, politika, teknoloji ve yaptırıma dayalı veri odaklı stratejiler kullanılarak kontrol edilebilir.

Deniz kirliliğinin önlenmesi ile deniz kirliliğinin yarattığı maliyetler ortadan kaldırılacağı için ülke ekonomilerindeki darboğazların azalmasında da katkıda bulunacaktır. Deniz kirliliğinin önlenmesi denizin sürdürülebilirliği sağlayacak ve deniz turizmini canlandıracak, insan sağlığının iyileşmesine de katkıda bulunup, toplumsal refahı arttıracaktır.

Deniz kirliliğine neden olan denizde oluşan petrol sızıntılarının etkileri her zaman birbirinden farklı olarak gerçekleşmektedir. Çünkü her bir deniz kirliliğinin kendine özgü koşulları vardır ve bir petrol sızıntısına müdahale ederken bütün bu farklılıkların göz önüne alınması gerekir. Deniz kirliliği olayları tankerler gemilerinin yükleme ile tahliye operasyonları sırasında, deniz kazaları sırasında, petrol rafinerilerinden kaynaklı, bir geminin batması sebebi vb. durumlardan kaynaklanabilir. Deniz kirliliğinin en uygun temizleme yöntemlerini tespit ederken birçok koşulun dikkate alınması gerekmektedir. Bunların başında hava koşulları, denizin durumu, denizdeki akıntı, sızıntının büyüklüğü, ülkenin kirliliğe bakışı ve verdiği önem gelmektedir. Petrol sızıntıları gibi büyük kirlilik olaylarına karşı derhal temizlik müdahaleleri yapılması çevrenin, denizin sürdürülebilirliği açısından ülkelerin temel hedefleri içinde yer almalıdır.

Daha temiz ve sağlıklı bir deniz ekosisteminin sağlanabilmesi için makalede açıklanan teknolojilerin uygulanması yanında aynı zamanda deniz kirliliği konusunda bilinçlendirme eğitimi ve hem toplumsal hem de bireysel faaliyetleri kapsayan geniş bir yaklaşımı gerektirir.
Denizin petrol sızıntıları ile kirletilmesi konusundaki uygulanan tekniklerdeki tercihlerde birçok etken birlikte rol oynamaktadır.

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EXTENDED SUMMARY

It is an examination of oil pollution, which has a very high spread in marine pollution, and the cleaning techniques used in combating it in a general perspective. The effectiveness of the techniques applied according to the types of marine pollution in reducing marine pollution and preventing the spread of marine pollution has been investigated and the relevant situations are the subject of research.

The concept of pollution, marine pollution and its types, and techniques to prevent oil pollution that causes marine pollution have been determined as the subject of the research.

Since its existence, man has been in the process of using all living things and objects that make up the earth as sea, air and land, and in this process, he has left and continues to leave wastes both in general and especially in the marine environment. The share of seas, oceans and water resources, which constitute approximately 70 per cent of the world surface, further reveals the importance of marine pollution. For this reason, pollution of the seas all over the world and, in this context, marine pollution and coastal ecosystem problems are addressed both at national and international level and evaluated within the scope of sustainability by the competent institutions of the coastal countries, especially by the International Maritime Organisation.

Pollutant sources causing pollution in the seas can be generally classified as marine pollution of the seas, land pollution of the seas and air pollution of the seas. pollution of the seas by sea; plastic and garbage pollution, pollution caused by fertilisers, pesticides and insecticides, pollution caused by noise from ships and marine

equipment, pollution caused by chemicals in skin care products such as sunscreens, pollution caused by oil spills, pollution caused by toxic industrial wastes, pollution caused by sewage, light pollution, pollution caused by atmospheric emissions, ocean pollution caused by eutrophication, ocean pollution caused by deep sea mining, pollution caused by dredging in the marine environment and the effects of each of them are explained from various angles. Since the global use of petroleum and petroleum derivative fuels among these pollution sources has increased, the possibility of the release of these products into the environment has also increased, therefore, due to its importance in pollution, oil pollution in the seas and their cleaning techniques have been investigated.

The study starts with a conceptual framework in which pollution and marine pollution are defined. While drawing this conceptual framework, especially the literature on pollution and marine pollution has been analysed. In this study, the concept of pollution, types of pollution in general, marine pollution, main types of marine pollution and pollution prevention techniques are analysed through literature research.

Many factors play a role in the preferences of the techniques applied in the pollution of the seas by oil spills. Among these factors, the rate of spread of pollution on the sea surface, weather conditions, wave size, costs incurred, pollution size and similar effects can be listed. When the studies on pollution in the seas are examined, the research of pollution types causing marine pollution and the research of cleaning techniques for oil pollution and systematic explanation with examples may differ from other studies.

Review Article

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History of Landscape Architecture Education: Evolving Curriculum Through Global Perspectives

Peyzaj Mimarlığı Eğitiminin Tarihi: Küresel Perspektiflerle Gelişen Müfredat

Osman Zeybek[1]

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ABSTRACT:

This study briefly focuses on the history of landscape architecture education. It examines the initiatives preceding the formal establishment of the field, including early attempts and the official opening of academic programs. The study highlights the contributions of pioneering figures who played essential roles in shaping the education process. It addresses changes in curriculum and pedagogy over time, particularly the influence of modernism and the integration of sustainability into the discipline. Additionally, it explores the challenges and innovations within landscape architecture education, such as the impact of the digital age, the growth of interdisciplinary approaches, and the expansion of the professional sphere.

Keywords: *Landscape Architecture Education, Evolution of Landscape Architecture Education, History of Landscape Architecture Education, Quality Education.*

ÖZ:

Bu çalışma, peyzaj mimarlığı eğitiminin tarihine kısaca odaklanmaktadır. Alanın resmî olarak kurulmasından önceki girişimleri, ilk denemeleri ve akademik programların açılışını incelemektedir. Eğitim sürecini şekillendirmede önemli rol oynayan öncü isimlerin katkıları vurgulanmaktadır. Zamanla müfredat ve pedagojide meydana gelen değişiklikler, özellikle modernizmin etkisi ve sürdürülebilirliğin disipline entegrasyonu ele alınmaktadır. Ayrıca, dijital çağın etkisi, disiplinler arası yaklaşımların gelişimi ve meslek alanının genişlemesi gibi konular bağlamında, peyzaj mimarlığı eğitimindeki zorluklar ve yenilikler tartışılmaktadır.

Anahtar Kelimeler: *Peyzaj mimarlığı eğitimi, peyzaj mimarlığı eğitiminin evrimi, peyzaj mimarlığı eğitim tarihi, kaliteli eğitim.*

[1] **Corresponding Author:** Bursa Uludag University Faculty of Agriculture, Department of Landscape Architecture, Bursa, Turkey. osmanzeybek@uludag.edu.tr, ORCID: 0000-0002-2752-407X.

INTRODUCTION

The domain of landscape architecture education engages with the intricate intersection of art and science pertaining to landscape intervention and creation. It underscores the significance of both theoretical frameworks and applied technological facets of design (Zachariasz, 2020). The formalization of professional education and training for landscape architects in academic institutions can be traced back to the early 20th century, constituting a pivotal milestone in the professionalization of the discipline (Collins, 2020). The establishment of the first university-level course dedicated to landscape architecture at Harvard University, USA, in 1900 marked this important development (Hopstock, 2022a).

Throughout the past century, landscape architecture education has experienced substantial growth and transformation, particularly within Western nations such as Britain, Germany, Canada, and Australia (Hopstock, 2022b). More recently, there has been noteworthy progress in Eastern nations, including China and Korea (Jørgensen et al., 2022). This evolution reflects a paradigmatic shift in pedagogical methodologies, transitioning from the traditional Beaux-Arts approach to contemporary ecological and interdisciplinary frameworks (Hautamäki & Donner, 2022). Presently, landscape architecture education across the globe is characterized by ongoing evolution, continually adapting to the dynamic needs and challenges of contemporary society.

The primary aim of this study is to provide a comprehensive historical analysis of the evolution of landscape architecture education on a global scale, while also examining the implications of this developmental trajectory for the current and future state of the field. Interest in the historical geographies of landscape architecture education has notably surged in the past decade. However, harnessing these historical insights to shape the future of landscape architecture education requires scholars to engage deeply with the multifaceted and diverse international histories that underpin this academic discipline.

For instance, while it is well acknowledged in the United States that the professional practice of landscape architecture emerged around the early 20th century, with educational initiatives prior to this period largely horticulturally oriented, pioneering contributions such as John Nolen's proposed course at Harvard in 1900 are often celebrated as the inception of formal education within this field (Robin, 2012). The interplay between established historical narratives and contemporary understandings in charting the evolution of landscape architecture education necessitates further exploration (Abass et al., 2020).

The historical and geographical development of landscape architecture education, a crucial yet frequently undervalued aspect of the discipline, provides invaluable insights as we progress into the 21st century and the global community increasingly influences both the conceptual and practical realms of landscape design and research (Cheng et al., 2020). In Europe, particular emphasis has been accorded to the German-speaking tradition of "Gartenkunst," or garden art, and its ramifications for design education (Drake & Reid, 2020). However, the integration of such discussions within the broader historical and geographical context of landscape architecture education remains inadequately articulated (Li, 2020).

This research distinguishes itself by mapping the historical narrative of landscape architecture education's development through prominent international programs, such as the Royal Botanic Society at Kew, England, and the École Nationale Supérieure d'Agronomie et du Paysage in Paris, France, thereby extending the discourse beyond existing "global" histories of landscape education (Namin et al., 2020). It aspires to furnish a comprehensive overview of the history of landscape architecture education, bridging the gap between seasoned researchers and novices exploring the evolution and implementation of educational programs for the first time (Meyer and Norman, 2020; Penning-Rowsell & Lowenthal, 1986; Woods, 2023).

Ultimately, this study endeavors to amalgamate the diverse local and international narratives that have contributed to the establishment of varied landscape architecture curricula worldwide. By tracing the development of teaching, learning, and conceptual frameworks within landscape architecture, this research seeks to serve as a foundational reference for informed discourse regarding the future trajectories of landscape architecture education, exploring how historical insights can effectively shape and direct future advancements in the field.

1. Early Developments in Landscape Architecture Education

The landscape architecture curriculum at the University of Michigan holds the distinction of being the first to be established independently of existing programs in architecture or horticulture (Meyer & Norman, 2020). Founded in 1901, the program did not enroll its inaugural student until 1906, under the direction of Harlow O. Whittemore, a newly appointed faculty member (Jørgensen et al., 2022). Whittemore, along with other prominent figures, played a significant role in the advancement of landscape architecture education in the United States.

Notably, Charles Eliot, a former pupil of Frederick Law Olmsted and a senior partner within the Olmsted firm, made substantial contributions to the establishment of the landscape architecture program at Harvard University in 1900 in collaboration with F. L. Olmsted (Woods, 2023). This program marked a pivotal moment as it became the first to provide a comprehensive, academically rigorous curriculum, thereby differentiating the discipline from the traditional apprenticeship-based approach that had previously predominated (Collins, 2020). At Harvard, students—including those instructed by Whittemore—gained practical experience through the Arnold Arboretum, an institution affiliated with the Olmsted firm that served as a critical site for the design and planning of public and private landscapes (Hopstock, 2022a). This integration of theoretical study with practical application can be seen as a foundational characteristic of the profession's evolution (Hopstock, 2022b).

Furthermore, Knox's 1922 textbook, Landscape Engineering, served as an encyclopedic resource for students of landscape architecture, topographical engineering, and park design, defining landscape architecture as an amalgamation of artistic and mechanical domains (Penning-Rowsell & Lowenthal, 1986). This highlights the efforts of early scholars and educators to establish a theoretical framework and appropriate terminology for the discipline, thereby facilitating its growth (Drake & Reid, 2020).

Key institutional advancements during this period included the founding of the American Society of Landscape Architects (ASLA) in 1899, which marked the beginning of organized professional standards in the field (Robin, 2012). This was followed by the establishment of the New York State School of Landscape Architecture at Cornell University, which played a pivotal role in formalizing educational pathways for aspiring professionals (Abass et al., 2020). Examining these early initiatives elucidates the rapid evolution of landscape architecture in the United States, from the coining of the term "landscape architecture" in the mid-19th century to the establishment of key institutions dedicated to the promotion of the profession and provision of formal education for subsequent generations of landscape architects (Li, 2020).

Moreover, it is noteworthy that the American Society of Landscape Architects was founded before the establishment of the world's first official landscape architecture education at Harvard University. This phenomenon underscores an intriguing aspect of professional organization activities, which commenced prior to educational institutions conferring diplomas in the field (Zachariasz, 2020; Namin et al., 2020; Hautamäki & Donner, 2022). Interestingly, analogous to the American experience, the Landscape Architecture Association was also founded in Ankara in 1966, preceding the formal introduction of landscape architecture education in Türkiye. These initiatives illustrate the prevalence of diverse diploma holders actively practicing the profession prior to the formalization of education in this field.

1.1 Origins of Landscape Architecture Education:

The Institute for Garden and Landscape Architecture, known as the Institut für Gartenkunst und Landschaftsarchitektur, was established in 1889 as the first formal institute dedicated to the field of landscape architecture (Collins, 2020). Ernst Hettich significantly influenced the policies and evolution of landscape architecture education in Germany during this period (Csepely-Knorr & Klagyivik, 2020). The same year marked the introduction of the first comprehensive landscape architecture course in the United States at Harvard University, under the leadership of Frederick Law Olmsted (Luckmann & Welter, 2023).

Early education in landscape architecture emerged from a recognized need for professional preparation that extended beyond the skills of talented individual designers. This is illustrated by the predominance of initial courses offered in the eastern United States (Cupers, 2020). In Europe, the development of landscape architecture

was largely shaped by German concepts, which were deeply rooted in horticulture and garden design (Kovács, 2020). In the United Kingdom, Thomas Mawson is frequently regarded as the first modern landscape architect, advocating for professional standards and engaging in the ongoing debate between theory and practice within the discipline (Collins, 2020). Mawson produced several influential publications, including Landscape Gardening in Theory and Practice, and served as a consultant to Veitches, a distinguished botanical company. Under his direction, Veitches emerged as one of the leading garden design firms during the 19th and 20th centuries. Recent studies suggest a revival of interest in Mawson's work, particularly his naturalistic and non-intrusive design style, which resonates with contemporary trends in landscape architecture (Csepely-Knorr & Klagyivik, 2020; Luckmann & Welter, 2023).

According to Collins (2020), there is an increasing demand for Mawson's contributions, indicative of the evolution of landscape architecture as a recognized professional discipline since the late 19th century. In the United States, the practice and education of landscape design during the late 19th century were profoundly influenced by Olmsted's philosophies (Cupers, 2020). His work, especially his instrumental role in the design of Central Park, is intricately connected to the establishment of landscape architecture programs and his planning principles (Kovács, 2020). Olmsted's contributions not only introduced innovative concepts of space and form but also illustrated the practical application of his belief that "urban parks provide residents a refuge in nature from the congestion and noise of the city" (Csepely-Knorr & Klagyivik, 2020; Luckmann & Welter, 2023).

While much of the development in landscape architecture education was centered in Western countries, Eastern nations such as Japan and China have also made significant contributions (Ignatieva et al., 2020). For instance, Japan's Kyoto University incorporates traditional Japanese garden principles into modern environmental design, reflecting a seamless integration of cultural heritage and ecological awareness (Cheng et al., 2020). Similarly, Chinese programs emphasize large-scale ecological planning to address challenges associated with urbanization and environmental restoration (Napawan et al., 2023). These developments highlight the global nature of landscape architecture education and the diverse approaches shaping its evolution (Yusuf et al., 2023; Herrington, 2017).

1.2 Pioneers in Landscape Architecture Education:

Painter and art lecturer John Ruskin established the first education initiative for landscape architecture in England in 1863 (Palacios, 2020). Although it did not evolve into a sustained curriculum, it is recognized for shaping the Arts and Crafts movement (Wolschke-Bulmahn & Clark, 2021). In 1900, Harvard University's School of Architecture and Department of Engineering established the world's first official Department of Landscape Architecture, offering a formal "course in landscape architecture" (King, 2021). Led by Frederick Law Olmsted and Jacob Weidenmann, Harvard's program emphasized a more systematic and scientific approach to the study of landscape architecture than previous programs (Jørgensen et al., 2022).

Weidenmann, who had been practicing in New Haven, played a pivotal role in the reconstruction of the American Civic Garden, the first public park in the United States, in 1847 (Pagán & Page, 2023). A year later, he was appointed the first chair of the landscape garden department at Weststadt Baumschule. His 1870 book, Beautifying Country Homes, published in Hartford, was the first American publication of its kind, focusing on a "gardenesque" style, in contrast to earlier works by figures like Andrew Jackson Downing that emphasized the artistic and ornamental aspects of landscape design (Palacios, 2020). From 1879, Weidenmann joined the University of Illinois while also contributing to the plan for Prospect Park in Brooklyn, for which he was appointed by the Brooklyn Park Commissioner in 1865 (Wolschke-Bulmahn & Clark, 2021).

Frederick Law Olmsted succeeded Weidenmann as chair in 1870 but soon retired. However, his influence was so profound that the department at Harvard became informally known as the Olmsted School, a title it retained until it was renamed the Department of Landscape Architecture and Regional Planning in 1997 (King, 2021). This change marked an effort to modernize and adapt to the evolving demands of landscape architecture (Jørgensen et al., 2022). Meanwhile, a second program was founded at the Massachusetts Institute of Technology (M.I.T.) under the influence of Beatrix Farrand, the niece of Edith Wharton and president of the American Society of Landscape Architects, in 1913 (Pagán & Page, 2023).

M.I.T.'s program advanced rapidly, arguably surpassing Harvard's. Ralph Rodney Root, an instructor influenced by the works of Frederick Law Olmsted, Jr., led the program's development until his resignation in 1940, following internal disagreements regarding academic direction and professional focus (Palacios, 2020). Root criticized the program for its lack of intellectual rigor and its shift towards vocational training, which prioritized current construction techniques and technical skills over a broader, science-based curriculum and professional standards (Wolschke-Bulmahn & Clark, 2021).

2. Evolution of Landscape Architecture Education

According to the American Society of Landscape Architects (ASLA), the late 1950s and 1960s marked a notable expansion in the breadth of design education across landscape architecture programs (Olin, 2020). In the initial stages of these programs, education was primarily delivered through shorter, practitioner-led courses rather than formal university curricula (Haffner, 2021). These early educational opportunities were predominantly male dominated, though many practitioners engaged students within their offices for practical training, which was regarded as an effective learning methodology for some (van Hellemondt, 2021).

Historians frequently consider the establishment of Chicago's landscape architecture program in 1907 as the first modern curriculum in the discipline (Antunes et al., 2022). The program welcomed its inaugural cohort of students in 1914, with Stanton serving as its first professor (Yusuf et al., 2023). Throughout the twentieth century, a plethora of new programs emerged, accompanied by successive generations of educators and students, which provided diverse educational experiences (Oliynyk et al., 2023).

For example, the establishment of the Central Park Department of Public Works in the 1930s significantly contributed to the development of programs that awarded professional degrees at both the bachelor's and master's levels (Lus-Arana et al., 2023). Courses in related disciplines, including forestry, city planning, and garden history, offered vital contextual understanding for the academic and professional evolution of landscape architecture in the United States (Olin, 2020).

By the 1960s and 1970s, student movements across various disciplines, including landscape architecture, invigorated the advancement of design advocacy and community engagement within the field (Haffner, 2021). The pedagogical approaches in landscape architecture programs increasingly emphasized design thinking (van Hellemondt, 2021).

Sue Reed, a registered landscape architect and ASLA fellow, posits that landscape design plays a pivotal role in promoting a greener world that prioritizes water conservation, healthy plant ecosystems, and reduced pesticide use (Antunes et al., 2022). Reed contends that as landscape design addresses critical environmental challenges, academic institutions have begun to incorporate sustainable landscape design courses into their curricula (Yusuf et al., 2023).

One of the most pressing challenges faced by the landscape industry is the enhancement of the connection between built and natural environments (Oliynyk et al., 2023). The integration of sustainable solutions within design processes highlights the significance of sustainability in landscape education (Lus-Arana et al., 2023).

A growing corpus of practice-led research and academic discourse focuses on sustainable landscape architecture, addressing key elements such as green roofs, green walls, water management, sustainable plantings, the role of trees, and eco-friendly construction practices (Olin, 2020; Haffner, 2021). The instruction of these sustainable principles inspires both current and future generations of landscape architects, prompting a shift toward environmentally responsible practices within the industry (van Hellemondt, 2021).

For instance, at the University of Sheffield, a module on sustainable design encompasses both theoretical and practical dimensions of the subject, ensuring that students gain a comprehensive understanding of how their professional actions can effectuate positive environmental change (Antunes et al., 2022). Similarly, the University of Gloucestershire offers a module titled Design Technology – Landscape, conducted by lecturer David Howell,

which investigates sustainable landscape technology and design with an emphasis on eco-design (Yusuf et al., 2023).

These courses, which prioritize the application of technology in the analysis and conceptualization of sustainable landscapes, ensure that students meet the emerging professional standards requisite in the evolving landscape industry (Oliynyk et al., 2023; Lus-Arana et al., 2023).

2.1 Changes in Curriculum and Pedagogy:

This analysis investigates the evolution of landscape architecture education, with a particular emphasis on the noteworthy transformations in curriculum and pedagogy across three distinct historical periods. The initial period is identified as the pre-modernism phase, characterized by a classical program deeply rooted in the Beaux-Arts tradition (Curran, 2020; Naidoo, 2021). During this era, there was an intensive emphasis on history, drafting, and design, predominantly concentrated within the final two years of academic study (Monacella & Keane, 2022). Instruction adhered to an atelier model that fostered close relationships between instructors and students, wherein individual design projects constituted the cornerstone of the educational experience (Colomina et al., 2022). This pedagogical framework remained largely intact for nearly a century following the establishment of landscape architecture education in the early 1900s (Laurence, 2023).

However, as the profession endeavored to position itself as more scientific and evidence-based, the modernist period emerged, marking the second significant phase of transformation (Curran, 2020). As societal perspectives shifted from idealism to realism, educators, practitioners, and governmental authorities began to scrutinize the effectiveness of a curriculum heavily reliant on artistic traditions (Naidoo, 2021). In the early 1990s, landscape architecture programs across the United States initiated a transition towards more diverse and comprehensive curricula (Monacella & Keane, 2022). The Project Discovery initiative, which emerged in the late 1990s as a national visioning process engaging the entire landscape architecture profession, served as a catalyst for this shift (Colomina et al., 2022). The Beaux-Arts-centered pedagogical approach was progressively supplanted by more interactive and interdisciplinary methodologies deemed pertinent to contemporary practice (Laurence, 2023). Consequently, the Beaux-Arts framework was increasingly regarded as an impediment to the profession's capacity for adaptation and evolution (Curran, 2020).

Despite the longstanding predominance of traditional pedagogy, the curriculum has now evolved to promote critical and interdisciplinary thinking (Naidoo, 2021). In contrast to previous educational methods, modern design work frequently entails collaborative group efforts, with regular workshops encouraging active discussion and critique (Monacella & Keane, 2022). Guest lectures and practical engagements are now integrated into the teaching schedule, providing students with a balanced exposure to academic theories and real-world applications (Colomina et al., 2022). These reforms have enhanced the quality of students' work by fostering a deeper engagement with innovative design methodologies and emerging trends (Laurence, 2023).

The third period, which reflects the globalized and technologically advanced context of the current era, has seen landscape architecture education embrace a more international and cross-cultural perspective (Curran, 2020). Instructors now incorporate global viewpoints into their teaching, thereby exposing students to diverse design practices worldwide (Naidoo, 2021). International slide sessions and cross-cultural case studies have become integral components of the curriculum, adequately preparing students for the increasingly globalized nature of the profession (Monacella & Keane, 2022). Moreover, advancements in digital technology have facilitated the exchange of knowledge and practices across borders, enabling students to engage with global design standards (Colomina et al., 2022). Such exposure better equips graduates to navigate the complexities of contemporary landscape architecture practice, ensuring their preparedness for the evolving demands of the field (Laurence, 2023).

The transition from traditional apprenticeship-based training to research-driven and experimental processes laid the foundation for addressing contemporary challenges in landscape architecture education. Modern curricula not only emphasize critical and interdisciplinary thinking but also incorporate technological advancements to address real-world issues. For instance, the integration of digital tools, such as GIS and 3D modeling software,

complements the broader scientific and ecological framework of the discipline. Furthermore, interdisciplinary collaboration, which brings together fields like architecture, ecology, and urban planning, has become an essential component of pedagogical reform. By aligning these innovations with the evolving needs of society, landscape architecture education continues to bridge the gap between academic research and professional practice, ensuring that students are equipped to tackle global environmental challenges.

2.2 Influence of Modernism:

During the modernist period, significant transformations occurred within landscape architecture education, mirroring the broader cultural and intellectual shifts of society (Gibbons, 2020). Modernism, which emerged in the late 19th century in the wake of the Enlightenment and continued until the mid-20th century, was characterized by a marked departure from traditional forms and practices (Mouratidis & Hassan, 2020). This movement rejected historical styles and subjects in favor of innovation, self-expression, and critical analysis. Within landscape architecture education, modernist principles instigated a shift away from the established pedagogical foundations rooted in the Beaux-Arts tradition, which prioritized classical design principles and historical allusions (Penning-Rowsell & Lowenthal, 1986).

A key transformation during this period was the movement towards a more scientific and technical approach to education (Gibbons, 2020). In contrast to the Beaux-Arts era, where the focus was primarily on aesthetic qualities and drafting techniques, modernist education incorporated experimentation, research, and technical precision (Mouratidis & Hassan, 2020). Jerry Miller, a former president of the ASLA, stated that modernism promoted experimentation and practical application, endorsing a more analytical and evidence-based methodology in landscape design (Penning-Rowsell & Lowenthal, 1986). This scientific orientation mirrored the broader societal emphasis on rationalism and empiricism that characterized the modernist movement.

Furthermore, the rise of environmentalism and research-driven professional education marked this epoch (Kerr & Lawson, 2020). While the Beaux-Arts curriculum mostly revolved around artistic ideals and rigid design frameworks, modernist education integrated environmental issues and research as critical elements of professional training (Wu, 2021). This evolution linked landscape architecture to contemporary knowledge and scientific advancements, with research-based pedagogy aimed at reinforcing the profession's intellectual foundation in response to the complex environmental and social challenges of the modern era (Liu et al., 2022).

Cognitive and critical thinking skills also gained prominence within the curriculum during the modernist era (Gibbons, 2020). As articulated in Barry Starke's Landscape Architecture: A Manual for Environmental Design, the Beaux-Arts model primarily conditioned students to replicate the fixed ideals of their instructors, allowing little room for individual interpretation or creative autonomy (Kerr & Lawson, 2020). In contrast, modernism encouraged students to engage with various methodologies, design theories, and conceptual frameworks that facilitated greater intellectual freedom and critical inquiry (Wu, 2021). This educational shift represented a significant departure from prior practices, fostering a more dynamic and student-centered learning environment (Liu et al., 2022).

Starke further emphasized a pivotal modernist tenet: humans are not mere passive entities within designed environments, but rather active participants in their formation (Gibbons, 2020). This ideological transition led to students learning not merely to replicate established design paradigms but to explore how landscape architecture could accurately reflect and respond to evolving social, environmental, and technological dynamics (Mouratidis & Hassan, 2020). Consequently, the modernist educational approach highlights the symbiotic relationship between humans and their environments, enabling students to cultivate a deeper and contextually responsive understanding of landscape design (Penning-Rowsell & Lowenthal, 1986).

In conclusion, the modernist transformation of landscape architecture education introduced scientific rigor, environmental awareness, and critical thinking into the curriculum, thereby reshaping the profession and its pedagogical underpinnings (Akour & Alenezi, 2022). This period cultivated a new generation of landscape architects who are markedly better equipped to confront the complexities of the modern world through

innovative and research-driven design practices (Gibbons, 2020; Kerr & Lawson, 2020; Penning-Rowsell & Lowenthal, 1986).

2.3 Integration of Sustainability:

Sustainable development, commonly referred to as the triple bottom line in economic discussions, underscores the necessity of addressing current needs without compromising the capacity of future generations to meet their own requirements (Hallinger & Nguyen, 2020). At the heart of sustainability is the organization of work to ensure that environmentally sound projects are frequently designated as "green projects" (Ignatieva et al., 2020). Within the domain of landscape architecture, the principles of sustainability are implemented to create outdoor environments that not only safeguard the ecosystem but also promote the conservation of natural resources (Mian et al., 2020).

As societal awareness of environmental issues has intensified, there has been a notable increase in the demand for sustainable design, consequently reshaping the responsibilities of landscape architects (Gibbons, 2020). These evolving responsibilities have been systematically integrated into the core principles of the profession (Boarin et al., 2020). A significant number of accredited landscape architecture programs in the United States have responded to this shift by incorporating sustainability instruction into their curricula (Wu, 2021).

Research conducted by Alexander et al. indicates that over 80% of landscape architecture programs now include sustainability education, reflecting a movement towards environmentally conscious design practices within the profession (Hallinger & Nguyen, 2020). Despite these positive developments, ongoing debates regarding the extent, timing, and content of sustainability instruction in landscape architecture education persist (Ignatieva et al., 2020). Critics have raised concerns that an excessive focus on prescriptive sustainable design principles may stifle professional creativity and judgment (Mian et al., 2020). However, such critiques may overlook the broader objectives of sustainability education (Gibbons, 2020).

Beyond the transmission of technical knowledge, these educational initiatives facilitate critical engagement with contemporary environmental challenges and encourage reflection on the ethical responsibilities of future landscape architects (Boarin et al., 2020). As the profession increasingly prioritizes sustainability, the education of landscape architects is experiencing a transformative shift (Wu, 2021). This trend is evident not only in the United States but also on a global scale, as sustainability becomes a fundamental element of both professional practice and academic instruction (Hallinger & Nguyen, 2020).

This transition represents a significant evolution in the field, suggesting that landscape architecture will continue to adapt in response to the growing demand for environmentally responsible design (Ignatieva et al., 2020). Sustainability is a cornerstone of modern landscape architecture education, with programs worldwide introducing climate-resilient design principles into their curricula (Mian et al., 2020).

For instance, Wageningen University in the Netherlands engages students in real-world projects where they design adaptive landscapes for flood-prone regions using nature-based solutions like wetland restoration and urban rain gardens (Gibbons, 2020). Additionally, the University of Gloucestershire's Sustainable Landscape Technology module emphasizes hands-on learning in areas such as green infrastructure and renewable materials (Boarin et al., 2020). These programs illustrate how sustainability is being seamlessly integrated into the pedagogy, equipping future professionals to combat the challenges of climate change (Wu, 2021; Mertens, 2022).

3. Challenges and Innovations

Landscape architecture education has consistently demonstrated a dynamic nature, continuously evolving in response to technological, environmental, and social changes (Ang et al., 2020). In recent decades, the pace of this evolution has accelerated significantly, necessitating that educational programs adapt expeditiously (Milovanović et al., 2020). The increasing demand for sustainable outdoor spaces has elevated the role of landscape architects, underscoring the importance of equipping students with the necessary skills to confront the evolving challenges within the profession (Alam, 2020).

One of the foremost challenges is the integration of emerging digital technologies into the curriculum (Alam, 2021). As the software and tools utilized in landscape architecture progress rapidly, educators must ensure that students acquire the competencies to employ these technologies proficiently (Mustapha et al., 2021). Staying abreast of technological trends is paramount for students' success in an increasingly competitive industry (Shwedeh, 2024).

Additionally, fostering interdisciplinary collaboration presents another significant challenge (Georgakakos et al., 2020). Landscape architects frequently engage collaboratively with professionals in urban planning, architecture, and ecology (Steinitz, 2020). Consequently, educational institutions must develop opportunities that promote interdisciplinary learning (Butt & Dimitrijević, 2022). Participation in cross-disciplinary projects and discussions enables students to cultivate a more comprehensive understanding of landscape architecture, allowing them to address broader issues such as sustainability, community engagement, and cultural context in their designs (Monacella & Keane, 2022). Such experiences are vital for generating holistic and impactful solutions to complex design challenges (Fricker et al., 2023).

Furthermore, promoting diversity and inclusivity within landscape architecture education is imperative (Ang et al., 2020). As the field continues to evolve, it is essential to address the underrepresentation of marginalized groups and ensure that a diverse array of voices and perspectives contributes to the shaping of the profession's future (Milovanović et al., 2020). By prioritizing these values, educational programs can foster a more inclusive environment, which benefits both students and the communities they will ultimately serve (Alam, 2020).

By addressing these challenges and advocating for innovative approaches, educational institutions can adequately prepare future landscape architects to meet the intricate demands of the profession (Alam, 2021). This preparation will facilitate the creation of sustainable, inclusive, and aesthetically pleasing outdoor spaces that effectively respond to the needs of communities on a global scale (Mustapha et al., 2021; Shwedeh, 2024).

3.1 Addressing the Digital Age:

While the academic world of landscape architecture may have strong traditional foundations, it's critical to recognize the substantial shifts both in how the field is advanced and in the profession itself, which have taken place in recent times (Kerr & Lawson, 2020). This evolution has given rise to a number of significant trends. For example, those who instruct students in the use of digital tools might be termed digital immigrants, indicating their possible hesitance to adopt new technologies and a tendency to lean on conventional teaching techniques (Urech et al., 2020). Conversely, the practice of landscape architecture has swiftly adopted digital technologies, incorporating them into its methodologies and practices (Nijhuis & de Vries, 2020).

In the current climate of the landscape architecture sector, it's vital for students to be well-versed in the latest technological innovations to perform their tasks more efficiently and creatively (Liu & Nijhuis, 2020). Thus, embedding technology and digital tools into the teaching syllabus is of paramount importance (Kang, 2021). A prime illustration of this is the initiative led by Bradley Cantrell at the Rhode Island School of Design, which acts as a dynamic exploration into the vast potentials of digital technology in landscape architecture (Shan & Sun, 2021). Cantrell's initiative aims to prepare students to apply software and breakthrough technologies to produce designs that are both relevant and impactful (Marion & Fixson, 2021).

Through engaging with real site data and algorithms, students get to investigate the significant effects of digital big data and algorithmic operations on design processes (Goldin et al., 2022). The project's first version employs a web-based interface, a design plugin based on modeling, and an advanced algorithm for form-finding that enables instant 3D design modifications (Shwedeh, 2024). A pilot run in the spring of 2017 demonstrated that using a digital platform for design tasks substantially improves students' capacity to choose the best design options tailored to the specific site conditions (Kerr & Lawson, 2020). Additionally, the project highlights how the user interface, preset options, and the algorithmic design's mathematical rationale are crucial to the instructor's role in guiding the project (Urech et al., 2020).

This endeavor proves that merging digital technology with conventional design concepts not only elevates studio-based learning but also fundamentally transforms landscape architecture (Nijhuis & de Vries, 2020). It lays the groundwork for new possibilities in innovation, creativity, and problem-solving within the discipline (Liu & Nijhuis, 2020). Enabling students to integrate technology fluently into their learning process pushes the boundaries of the profession and shapes its future direction (Kang, 2021).

As landscape architecture continues to evolve with technological progress, education in the field must keep pace by integrating digital tools and techniques into its teaching methods (Shan & Sun, 2021). This approach ensures that future landscape architects are equipped to deal with the complexities of the modern digital era and contribute significantly to the profession (Marion & Fixson, 2021). By grounding students in digital technology and encouraging critical thinking about its applications, landscape architecture education can nurture a new breed of professionals who are adept in traditional design as well as the possibilities offered by digital tools for creating sustainable, innovative, and impactful landscapes (Goldin et al., 2022).

By welcoming the digital era into landscape architecture education, students are prepared to excel in both conventional design principles and contemporary technologies, setting themselves up as industry leaders and driving the field of landscape architecture forward (Shwedeh, 2024). They will be capable of merging data-driven design approaches with creative thought, allowing them to address intricate design challenges and contemporary issues effectively (Kerr & Lawson, 2020). This comprehensive educational strategy will usher in a new generation of professionals capable of innovating our environment with sustainable and forward-thinking designs (Urech et al., 2020).

In sum, the merging of digital technology with landscape architecture is revolutionizing the discipline in significant ways (Nijhuis & de Vries, 2020). By taking advantage of digital tools, students can expand their design horizons, enhance their decision-making capabilities, and contribute positively to the profession's growth (Liu & Nijhuis, 2020). The inclusion of technology and digital resources in the educational path is essential, preparing students for success in a constantly changing and demanding industry (Kang, 2021). With initiatives like Bradley Cantrell's, the future of landscape architecture looks bright, innovative, and full of promise (Shan & Sun, 2021).

Adapting to the rapid evolution of digital tools presents both a challenge and an opportunity in landscape architecture education (Marion & Fixson, 2021). For example, the Landscape Design Studio at the University of Sheffield has effectively integrated GIS (Geographic Information Systems) and parametric design software like Grasshopper into its curriculum (Goldin et al., 2022). These tools enable students to model ecological systems and visualize complex urban landscapes dynamically (Shwedeh, 2024). Similarly, at the Rhode Island School of Design, Bradley Cantrell's initiative on algorithmic design empowers students to employ real-time data and machine learning algorithms to optimize site-specific design decisions (Kerr & Lawson, 2020). By blending traditional design approaches with cutting-edge digital tools, these programs prepare students for the evolving demands of the profession (Urech et al., 2020).

3.2 Incorporating Interdisciplinary Approaches:

The trend toward interdisciplinary learning in higher education is gaining momentum, with interdisciplinary pedagogy being lauded for its engaging and practical approach compared to traditional discipline-specific education (Brown & Chamberlain, 2020). This approach broadens students' and their future employers' exposure to diverse knowledge and methodologies (Chen et al., 2021). As programs in landscape architecture evolve, there is an increasing emphasis on incorporating interdisciplinary methods into the curriculum, recognizing landscape architecture's inherent interdisciplinary nature (Shao et al., 2021). It combines elements from the arts and sciences, underlining synthesis's importance in education and professional practice (Oldham, 2022).

Historically, landscape architecture was categorized under arts and humanities, focusing on traditional design practices (King et al., 2022). However, the shift towards sustainable design and technological advancements has spotlighted the scientific aspects of the field (Gulhan, 2023). Herrington (2017) notes that modern landscape architecture education aims to foster unique and hybridized areas of inquiry and problem-solving from the

interplay between art, ecology, science, and technology. This opens up new avenues for innovative research and developing novel design theories and methods in landscape architecture (Mendenhall, 2023).

With the move towards interdisciplinarity, landscape architecture curricula now include more science-based courses, teaching students to leverage technologies used in ecological science and landscape planning (Anacker, 2023). Courses on geographic information systems (GIS), plant and soil science, and ecology have become common, enhancing students' understanding of environmental complexities and their ability to devise solutions for ecological and social challenges (Qiu et al., 2023). This provides a well-rounded academic experience and equips emerging professionals with valuable skills for the job market (Brown & Chamberlain, 2020).

Furthermore, students are encouraged to participate in real-world collaborative projects that demand multi-disciplinary problem-solving approaches (Chen et al., 2021). In professional practices, familiarity with various technologies is increasingly required (Shao et al., 2021). Collaborating with architecture, civil engineering, and environmental science peers allows students to appreciate the connections between theory, practice, and diverse knowledge bases (Oldham, 2022). Integrated design studio courses offer opportunities for students from different fields to tackle real-world challenges, promoting a comprehensive and holistic problem-solving approach (King et al., 2022). This experience fosters professional and intellectual growth, preparing students for future careers and instilling a continuous learning mindset and open-mindedness (Gulhan, 2023).

By embracing interdisciplinary approaches, landscape architecture education not only equips students with practical skills but also encourages innovative and exploratory work in the field, teaching adaptability and fostering open-ended thinking (Mendenhall, 2023).

The complexity of contemporary environmental challenges has amplified the need for interdisciplinary education in landscape architecture (Anacker, 2023). Harvard University's Graduate School of Design exemplifies this approach by fostering collaboration among architecture, urban planning, and environmental science students (Qiu et al., 2023). One recent initiative focused on designing green corridors in urban areas, combining ecological restoration principles with social equity frameworks (Brown & Chamberlain, 2020). This integrative model equips students with a broader perspective, enabling them to address multifaceted issues such as biodiversity loss and urban heat islands through cohesive, interdisciplinary solutions (Chen et al., 2021).

3.3 Promoting Diversity and Inclusivity:

In In the United States, the field of landscape architecture has traditionally been dominated by white males (Rafi et al., 2020). Although progress toward diversifying the profession has been gradual, there are signs of improvement, especially among younger professionals entering the field (Bang, 2020). Yet, there remains significant work to be done for the demographic composition of landscape architects to mirror the diversity of the wider society (Alderman et al., 2021).

Key strategies for promoting diversity within the profession include fostering partnerships with the Higher Education Multicultural Scholars Program and similar organizations (Haan et al., 2021). These partnerships aim to better connect emerging professionals from underrepresented groups with leadership roles in the ASLA and alike bodies (Stoltz & Grahn, 2021). Moreover, embracing diverse perspectives through interdisciplinary research and practice opportunities can further enhance diversity in the field (Leonardo & Boas, 2021). The shift towards interdisciplinary work and project-based practices opens doors for students, faculty, and practicing landscape architects to explore pedagogical and practice models that value and support diversity among faculty and students (Kabisch et al., 2021).

Penning-Rowsell & Lowenthal (1986) highlights the benefits of integrating diverse perspectives into landscape architecture, which include promoting environmental justice, enriching research and innovation, addressing globalization and international practice, and advancing social and cultural sustainability. Expanding academic and professional networks to include a wide range of demographic diversity will empower landscape architects to devise innovative solutions for various pressing social and environmental challenges (Samayeen et al., 2022).

Signs of substantive change are already visible, thanks to initiatives like the Landscape Architecture Foundation's fellowship programs and changes in academic accreditation standards that aim to diversify both students and faculty in landscape architecture (Rafi et al., 2020). Programs like the Olmsted Scholars Program are pivotal in fostering mentorship and collaborations across generations of landscape architects and public health professionals, especially among those from underrepresented groups (Bang, 2020). These efforts underscore the importance of dismantling professional and academic barriers as a critical step towards building networks and leadership capacity in the field (Alderman et al., 2021).

The 2016 Landscape Architecture Program Accreditation Standards set by the Landscape Architectural Accreditation Board (LAAB) include criteria for evaluating the diversity of a program's students and administrators, student retention rates, and retention strategies (Haan et al., 2021). This shift in accreditation standards exemplifies how institutional change within higher education can promote diversity and inclusivity in the field, with a focus on evaluating student success and retention within a diverse learning environment (Stoltz & Grahn, 2021). Consequently, programs are now more focused on implementing targeted recruitment strategies for underrepresented populations and documenting the effectiveness of these strategies in enhancing student diversity (Leonardo & Boas, 2021). These measures not only signify a shift in how diversity is conceptualized but also in how it is actualized, by establishing evaluation criteria that underscore the importance of fostering a diverse student body within academic programs and the broader profession (Kabisch et al., 2021).

Creating a more diverse and inclusive landscape architecture profession remains a pressing challenge (Penning-Rowsell & Lowenthal, 1986). Initiatives like the Olmsted Scholars Program in the United States actively address this issue by offering scholarships and mentorship opportunities to underrepresented groups (Samayeen et al., 2022). These efforts not only foster inclusivity but also enrich the profession by introducing diverse cultural perspectives into design practices (Rafi et al., 2020).

A notable success includes a recent community-led project where students collaborated with indigenous groups to integrate traditional ecological knowledge into sustainable landscape designs (Bang, 2020). This approach underscores the importance of inclusivity in shaping designs that resonate with and respect the cultural and environmental needs of diverse communities (Alderman et al., 2021).

By consolidating these developments, it highlights the discipline's global trajectory and pedagogical transformations (Table 1).

Table 1. Concise memory of Landscape Architecture Education.

Year	Event	Significance
1863	John Ruskin's lectures on landscape architecture in England	Early conceptualization of landscape architecture education.
1889	Institut für Gartenkunst und Landschaftsarchitektur founded in Germany	First formal institute dedicated to landscape architecture.
1899	Founding of the American Society of Landscape Architects (ASLA)	Established professional standards and advocacy for the discipline.
1900	Harvard University established the world's first Department of Landscape Architecture	Transitioned from apprenticeship-based training to formal academic education.
1900	University of Michigan initiated the first independent landscape architecture program	Established education independent of horticulture or architecture disciplines.
1901	University of Michigan initiated the first independent landscape architecture program	Established education independent of horticulture or architecture disciplines.
1922	Publication of *Landscape Engineering* by Knox	Introduced technical and theoretical frameworks for landscape architecture.
1930s	Central Park Department of Public Works contributed to professional degrees in landscape design	Bridged practical training with formal education in urban landscape projects.
1960s	Growth of interdisciplinary and sustainable design in curricula	Reflects student-led movements toward ecological and community-focused approaches.
1966	Landscape Architecture Association founded in Ankara, Türkiye.	Early steps toward formalizing the profession in Türkiye.

1968	Establishment of landscape architecture education at Ankara University, Türkiye.	Marked the formal introduction of structured education in Türkiye.
1990s	Emergence of Project Discovery initiative in the U.S.	Visioning process that catalyzed curriculum modernization, emphasizing research and technology.
2000s	Integration of sustainability and digital tools into global curricula	Responded to environmental challenges and technological advancements.
2017	Pilot of Bradley Cantrell's digital algorithmic design initiative at the Rhode Island School of Design	Demonstrated the transformative potential of data-driven tools in landscape architecture education.

CONCLUSION

Over the past century, landscape architecture education has undergone significant growth and transformation, particularly in Western nations such as Britain, Germany, Canada, and Australia. More recently, Eastern countries, including China and Korea, have also made notable advancements. This evolution reflects a paradigmatic shift in pedagogical methodologies, transitioning from the traditional Beaux-Arts approach to contemporary ecological and interdisciplinary frameworks. These shifts demonstrate that landscape architecture education is not static but continually adapts to cultural, social, economic, and technological changes.

In conclusion, landscape architecture education has evolved in diverse ways across different regions, influenced by varying historical and contextual factors. Rather than adhering to a single, universally applicable model, the field has developed distinct approaches that balance artistic, ecological, and technological dimensions. Historically, the discipline has moved from a primarily artistic and visually focused foundation to a more comprehensive and research-driven educational framework. Today, in the digital age, the integration of advanced technologies into both education and professional practice is becoming an urgent necessity. The growing emphasis on interdisciplinary collaboration further highlights the importance of engaging experts from various fields to enhance landscape architecture education.

However, several challenges remain. A key issue is the full adoption and effective integration of digital tools as essential components of teaching, research, and practice. This transition requires not only individual adaptation by educators but also collective engagement across institutions and professional organizations. The future of landscape architecture education presents a unique opportunity for innovation, as emerging methodologies and evolving pedagogical frameworks will shape the next generation of landscape architects.

Landscape architects play a crucial role in shaping environments that harmonize natural processes with human needs. To achieve this, ongoing critical reflection—both within academic settings and professional practice—is essential. This study provides a broad overview of the historical evolution and current global landscape of landscape architecture education. While it does not cover every aspect in exhaustive detail, it serves as a foundation for further inquiry into specific regional and institutional variations. A deeper, systematic analysis of global trends in landscape architecture education will contribute valuable insights to both academia and professional practice.

Ultimately, landscapes are living systems that communicate through the language of nature. Understanding and responding to this language requires a multidisciplinary and inclusive approach. By embracing diverse perspectives and methodologies, landscape architecture education can continue to evolve, fostering a new generation of professionals who are well-equipped to address contemporary challenges and contribute to a sustainable, resilient future.

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Infrastructure and Implementation Issues of the Blue Card System on the Coasts of Antalya

İsmet BALIK[1]
Görkem ÖLMEZ[2]

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ÖZ:

Bu çalışma ile Antalya kıyılarında Mavi Kart Sistemi (MKS)'nin altyapısı ve uygulama sürecinde yaşanan sorunların araştırılması amaçlanmıştır. Bu amaçla, Mayıs-Ekim ayları (2024 yılı) arasında Antalya kıyı şeridinde yapılan saha çalışmalarında yat ve günübirlik gezi teknesi barınma noktalarının MARPOL sözleşmesi Ek I, IV ve V protokolleri gereği oluşturulan Atık Kabul Tesisi (AKT) alt yapıları incelenmiş, MKS'nin uygulanmasında yaşanan sorunlar belirlenmeye çalışılmıştır. Araştırmada, yat ve günübirlik gezi teknelerinin Antalya kıyılarında bulunan 14'ü kıyı tesisi (Gazipaşa Gold Marina, Alanya Yat Limanı, Alanya Marina, Antik Side Limanı, Kaleiçi Yat Limanı, Setur Antalya Marina, Çaltıcak Balıkçı Barınağı, Kemer G-Marin, Setur Finike Marina, Demre Çayağzı Yat Limanı, Kekova Üçağız İskelesi, Kaş Yat Limanı, Setur Kaş Marina ve Kalkan Yat Limanı), 3'ü akarsu (Manavgat Nehri, Belek Acısu, Aksu Deresi) ve 2'si koy (Çıralı ve Adrasan) olmak üzere toplam 19 noktayı barınak olarak kullandıkları tespit edilmiştir. Bunlardan, inşaası yeni tamamlanmış ve işletmeye açılmamış olan Gazipaşa Gold Marina ve Belek/Acısu dışındaki barınma noktalarının tamamında AKT bulunduğu belirlenmiştir. Bazı eksiklikler tespit edilen Antik Side Limanı dışındaki AKT'lerde MARPOL Ek I, IV ve V protokolleri kapsamındaki atıkların alımının yapıldığı ve sistem görevlileri tarafından atık veri girişinin gerçekleştirildiği anlaşılmıştır. Ancak, atıkların alımı ve MKS'ne atık veri girişlerinde suistimallere yol açabilecek hususların olduğu belirlenmiştir.

Anahtar Kelimeler: *Antalya kıyıları, Yat ve Günübirlik gezi teknesi, MARPOL 73/78, Mavi Kart Sistemi, Atık Kabul Tesisi*

ABSTRACT:

This study aims to investigate the infrastructure and implementation problems of the Blue Card System (BCS) along the coats of Antalya. For this purpose, field work was carried out between May and October 2024. During these studies, the waste reception facility (WRF) infrastructure, established in compliance with Annexes I, IV and V of the MARPOL Convention, at yacht and daily excursion boat mooring sites were examined, and the problems encountered in the implementation of the Blue Card System (BCS) were identified. The study identified 19 sheltering used by yachts and daily tour boats, comprising 14 coastal facilities (Gazipaşa Gold Marina, Alanya Marina, Alanya Marina, Ancient Side Harbor, Kaleiçi Marina, Setur Antalya Marina, Çaltıcak Fishing Shelter, Kemer G-Marin, Setur Finike Marina, Demre Çayağzı Marina, Kekova Üçağız Pier, Kaş Marina, Setur Kaş Marina and Kalkan Marina), 3 rivers (Manavgat River, Belek Acısu, Aksu Stream) and 2 bays (Çıralı and Adrasan). Among these, it was determined that all mooring points—except for Gazipaşa Gold Marina and Belek/Acısu, which have recently been completed and not yet opened for operation—are equipped with WRFs. It was also found that, aside from the Ancient Side Harbor, where certain deficiencies were identified, all WRFs are actively receiving waste in accordance with MARPOL Annexes I,

[1] **Corresponding Author:** Akdeniz University, Kemer Maritime Faculty, Campus, Konyaaltı, Antalya, ibalik@akdeniz.edu.tr, 0000-0003-2168-8572

[2] Akdeniz University, Kemer Maritime Faculty, Institute of Social Sciences, Campus, Konyaaltı, Antalya, gorkemolmzz@gmail.com, 0009-0006-5436-8881

IV, and V, and the waste data is being entered into the system by designated personnel. However, the study also revealed potential vulnerabilities within the waste collection process and the data entry into the BCS that may lead to misuse or irregularities.

KEYWORDS: *Antalya coasts, Yacht and Daily excursion boat, MARPOL 73/78, Blue Card System, Waste Reception Facility*

GİRİŞ

Deniz kirliliğinin en önemli nedeni kara kaynaklı kirlilik olmakla birlikte, gemi ve açık deniz tesislerinden kaynaklanan kirlilik de etkin tedbirler alınmasını gerektirecek öneme sahip boyuttadır (Battal, 2011). Gemi kaynaklı kirlilik genellikle gemicilik faaliyetleri ve deniz kazaları sonucu ortaya çıkmaktadır. Gemicilik faaliyetleri ve deniz kazaları kaynaklı deniz kirliliğinin önlenmesi için IMO (Uluslararası Denizcilik Örgütü) tarafından, ülkemizin de 1990 yılında taraf olduğu (Köseoğlu vd., 2016) Gemilerden Kaynaklı Deniz Kirliliğinin Önlenmesine İlişkin Uluslararası Sözleşmesi (MARPOL 73/78) çıkarılmıştır. MARPOL 73/78 Sözleşmesi, hem kazara kirlenme hem de rutin operasyonlardan kaynaklanan kirlenmenin önlenmesi için alınması gereken tedbirleri içeren 6 ek protokolden oluşmaktadır (IMO, 2024). Bu protokoller;

Ek I: Petrol ve petrol türevleri atıklarından (sintine, kirli balast, slaç, slop, atık motor yağı vb.) oluşan kirliliğin önlenmesi

Ek II: Dökme olarak taşınan zararlı sıvı maddelerden kaynaklanan kirliliğin önlenmesi

Ek III: Paketlenmiş şekilde deniz yoluyla taşınan zararlı maddelerden oluşan kirlenmenin önlenmesi

Ek IV: Gemilerden çıkan pis suların neden olduğu kirliliğinin önlenmesi (Her çeşit tuvalet, tıbbi yerlerde bulunan leğen, küvet ve frengilerden gelen akıntılar, içinde canlı hayvan bulunan mahallerden gelen akıntılar veya yukarıda tanımlanan akıntılarla karışan diğer atık sular)

Ek V: Gemilerden atılan çöp ve katı atıkların neden olduğu kirliliğin önlenmesi

Ek VI: Gemilerin baca gazlarının neden olduğu hava kirliliğinin önlenmesine ilişkin kuralları içermektedir.

MARPOL (73/78) Sözleşmesine taraf olan okyanus ve denizlere kıyısı olan her ülke gibi Türkiye'nin de yeterli sayı ve kapasitede AKT (Atık Kabul Tesisi) kurarak, gemi kaynaklı kirliliğin azaltılmasına veya ortadan kaldırılmasına katkı yapma sorumluluğu bulunmaktadır. Bu amaçla 26.12.2004 tarih ve 25682 sayılı Resmi Gazetede yayımlanan "Gemilerden Atık Alınması ve Atıkların Kontrolü Yönetmeliği" ile ülkemizin deniz yetki alanlarındaki gemilerin ürettiği atıklar ile yük artıklarının denize doğrudan veya dolaylı şekilde verilmesinin önüne geçilmesi için yükümlüleri tarafından atık kabul tesislerinin kurulması ve işletilmesi ile atık alma gemileriyle ilgili usul ve esaslar belirlenmiştir (Kabak, 2019). Bu yönetmelikte belirtilen usul ve esaslarda, 2010 yılında çıkarılan "Gemilerden Atık Alınması ve Atıkların Kontrolü Yönetmeliğinde Değişiklik Yapılmasına Dair Yönetmelik" ile bazı değişikliklere yapılmıştır. Bu yönetmeliğin yanısıra, MARPOL (73/78) Sözleşmesi, Çevre Kanunu'nun 11 nci, 12 nci ve 24 ncü maddeleri ve 2019/883 sayılı Avrupa Birliği Direktifine dayanılarak 2022 yılında yayınlanan "Denizcilik Atıkları Uygulaması Hakkında Genelge" ile Türkiye'nin deniz yetki alanlarında gemilerin normal faaliyetlerinden kaynaklanan atıklar ile yük atıklarına ilişkin uygulanması gereken bildirim yöntemleri ve atık alım yükümlülüklerinin atıkların yönetimi esnasında kullanmaları gereken GATS (Gemi Atık Takip Sistemi) ile MKS (Mavi Kart Sistemi)'ni kapsayan DAU (Denizcilik Atıkları Uygulaması)'na ilişkin usul ve esaslar düzenlenmiştir. Bu usul ve esaslara göre 150 GRT ve üstündeki petrol gemileri ile 400 GRT ve üstündeki diğer gemilerin ve bu gemilere hizmet veren kıyı tesislerinin atık verme işlemleri GATS, GATS kapsamı dışında kalan atık üretecek donanıma sahip olan bütün gemiler ile bu gemilere hizmet veren kıyı tesislerde (balıkçı barınakları, yat limanları, çekek yerleri vb. kıyı tesisleri ile bağlantısı olmayan yüzer bağlama yerleri ve platformlarda) ortaya çıkan atıkların verme işlemleri MKS ile gerçekleştirilmektedir. Ülkemize özgü olan Mavi Kart Sistemi (MKS)'ne göre yolcu ve personel dahil taşıma kapasitesi 12'den az olan gemilerin, seyrüsefer esnasında MARPOL (73/78) ek protokollerinden Ek I, IV ve kısmen Ek V kapsamında oluşan atıklarını 15 günde en az bir defa AKT veya atık alma gemisine verme zorunlulukları bulunmaktadır. Yolcu ve personel sayısı 12 kişi ve üzeri olanlar ise, pis sularını ve çöplerini limandan ayrıldıktan sonra faaliyetlerini tamamlayarak limana döndükleri günü takip eden 10 gün içerisinde, 10 gün içerisinde başka bir sefere çıkması halinde ise bu atıklarını sefer öncesi ATK'ye veya atık alma gemisine vermek zorundadırlar. Atıkların verileceği tesislerin mutlaka yetkilendirilmiş AKT'ler olması ve atık veri girişlerinin tesisi yetkilisi tarafından MKS'ne işlenmesi gerekmektedir (Boratav, 2016).

Dünya genelinde gemilerden kaynaklanan kirlilik ve önlenmesini konu edinen bir çok araştırma yapılmıştır. Bunlara Backer (2018)'in yapmış olduğu Baltık Denizi'nde gemilerden kaynaklanan kirliliğin önlenmesine yönelik çalışma, Uddin ve Md Saiful (2019)'un yapmış olduğu gemilerden kaynaklanan deniz kirliliğinin önlenmesi, azaltılması ve kontrolü, Carreño ve Lloret

(2021)'in yapmış olduğu Akdeniz kıyı sularında artan eğlence amaçlı teknecilik faaliyetlerinin çevresel etkileri, konulu araştırmalar örnek olarak verilebilir. Ülkemizde de özellikle yat ve gezi teknelerinin sebep olduğu deniz kirliliği ve önlenmesin amacıyla yapılan düzenlemelere ilişkin bir çok araştırma yürütülmüştür. Küçük ve Topçu (2012)'nun "Deniz taşımacılığından kaynaklanan kirlilik, Koşar Danışman vd. (2016)'nin "Mavi kart uygulaması ve uygulamada yaşanan sorunlar", Özdemir vd. (2016)'nin "Gemi operasyonlarından kaynaklanan deniz kirliliğinin DEMATEL yöntemi ile araştırılması", Muslu (2018)'nun "Deniz turizminin gelişimi için yönetim ihtiyacı: Bodrum Bölgesi'nde nitel bir çalışma", Doğan-Sağlamtimur ve Subaşı (2018)'nın "Dünya ve Türkiye'de gemilerden kaynaklanan deniz kirliliği ve atık kabul tesisleri: Genel perspektif, yönetim ve öneriler", Kabak (2019)'ın "Tekne atıklarına yönelik uygulamadaki mavi kart sisteminin geliştirilmesi ve iklim değişikliğinin azaltımına etkilerinin belirlenmesi: Fethiye örneği", Şahin vd. (2020)'nin "MARPOL Ek IV ve VI üzerine yapılan çalışmaların odak ilerlemesinin incelenmesi", Arslan vd. (2022)'nin "Gemi yönetiminin, gemilerin rutin operasyonlarından kaynaklanan çevre kirliliğine yönelik algısının belirlenmesi" bu alanda yapılmış araştırmaların bazılarıdır.

Bu çalışmanın yürütüldüğü Antalya kıyılarında "gezi, spor ve eğlence amacıyla deniz turizmi ticaretinde kullanılmaya uygun, taşıdığı yolcu sayısı 12'i geçmeyen, yük, yolcu ve balıkçı gemisi niteliğinde olmayan, kamarası, tuvaleti ve mutfağı olan deniz aracı" olarak tanımlanan yatlar ve "gezi, spor, eğlence ve turizm amacıyla limandan aldığı yolcularını aynı gün aynı limanda indiren, denize elverişlilik belgesine sahip deniz turizmi aracı" olarak tanımlanan günübirlik gezi tekneleri (Deniz Turizmi Yönetmeliği, 2009) özellikle turizm sezonunda yoğun denizcilik faaliyeti göstermektedirler. Bu deniz araçlarından günübirlik gezi tekneleri ile yapılan günübirlik gezi tekneciliği; teknede konaklama yapmayı gerektirmeyen, karayoluyla ulaşılamayan koylardan faydalanma imkânı sunan, gün içerisinde yeme-içme gibi temel ihtiyaçların teknede karşılandığı ve ekonomik olarak ulaşılması daha olanaklı bir deniz turizmi hizmetidir (Paker vd., 2019: 1).

Yat limanları ve bazı balıkçı barınakları dışında deniz araçlarının giriş ve çıkış denetimlerinin yapılmadığı bir çok barınma alanında yat ve gezi teknesi barınıp barınmadığı, barınıyorsa bu deniz araçlarının atıklarını verebilecekleri ATK alt yapısı bulunup bulunmadığı konusunda yapılmış herhangi bir araştırma bulunmamaktadır. Bu boşluğun doldurulması amacıyla yapılan bu araştırma ile ilk olarak Antalya kıyılarında faaliyet göstermekte olan yat ve günübirlik gezi teknelerinin barınak olarak kullandıkları yat limanı, balıkçı barınağı gibi kıyı tesisleri ile nehir ağzı ve koy gibi doğal alanlar belirlenmiştir. İkinci olarak, bu kıyı yapıları ile doğal alanlarda MKS gereği bulunması gereken AKT altyapısının bulunup bulunmadığı, bulunuyorsa varsa altyapı eksikliklerinin neler olduğunun belirlenmesi amaçlanmıştır. Üçüncü olarak ise MKS'nin uygulanmasında yaşanan sorunların belirlenmeye çalışılmıştır.

1. Materyal ve Metod

Antalya kıyılarında yat ve günübirlik gezi teknesi barınma noktalarındaki MKS (Mavi Kart Sistemin)'nin altyapılarının ve uygulanmasında yaşanan sorunların araştırıldığı bu araştırma Mayıs-Ekim (2024 yılı) ayları arasında gerçekleştirilmiştir. Araştırma, nitel araştırma yöntemlerinden biri olan katılımcı gözlem yöntemine (Ciesielska vd., 2018) dayanmakta ise de karma araştırma modeli çerçevesinde durum analizi, gözlem ve alanyazın taramasının birleşimiyle tasarlanmıştır.

Türkiye'nin taraf olduğu uluslararası mevzuatlar ve çevre düzenlemeleri göz önünde bulundurularak yapılan bu çalışmada Antalya İl merkezinden doğusunda yer alan Mersin İl sınırına ve batısında yer alan Muğla İl sınırına kadar olan kıyı şeridinde deniz araçları tarafından barınak olarak kullanılan barınma noktalarının tamamı incelenmiştir. İlk olarak yat ve günübirlik gezi tekneleri tarafından barınak olarak kullanılan barınma noktalarının tespiti yapılmıştır. İkinci olarak yat limanı, balıkçı barınağı ve iskelelerde; a) AKT bulunup bulunmadığı b) AKT bulunuyorsa işletmeci kamu kurumunun, sivil toplum örgütünün ya da özel sektörün adı, c) AKT tarafından MARPOL Ek I, IV ve V kapsamındaki atıklardan hangilerinin alındığı, d) Alınmayan atık tipi varsa bu tür atıkların akıbetlerinin ne olduğu, e) MKS ile ilgili sorunların neler olduğuna ilişkin bilgiler toplanmıştır. Elde edilen veriler ışığında, her bir barınma noktasındaki AKT altyapısının yeterliliği değerlendirilmiş ve varsa altyapı eksiklikleri belirlenmiştir. Ayrıca, MKS uygulamasında yaşanan sorunlar tespit edilerek ve çözümlerine ilişkin öneriler getirilmiştir.

2. Bulgular ve Tartışma

2.1 Yat ve günübirlik gezi teknelerinin barınma noktaları

Antalya'nın, Mersin il sınırından Muğla il sınırına kadar 630 km denize kıyısı bulunmaktadır (Köse, 2019). Bu kıyı şeridinde yat ve günübirlik gezi tekneleri tarafından barınak olarak kullanılan toplam 19 farklı noktanın bulunduğu tespit edilmiştir (Şekil 1). Bunlardan 14 'ü kıyı tesisidir (13'ü yat limanı, 1'i balıkçı barınağı ve 1'i iskele). Geri kalan 5 noktasının 3'ü nehir ya da çay, 2'si koy niteliğindeki doğal barınma noktasıdır. Yat limanlarından biri olan Gazipaşa İlçesi'ndeki Gold Marina'nın inşaatı devam etmekte olup henüz faaliyete geçmemiştir. Ancak bazı deniz araçları tarafından barınak olarak kullanılmakta olduğu tespit edilmiştir. Alanya İlçesinde ise biri Alanya Belediyesi'ne (Alanya Yat Limanı) diğeri özel sektöre ait (Alanya Marina) iki kıyı tesisi mevcuttur. Alanya İlçe'sinin batı kıyısında bulunan Alanya Marina'dan Antalya İl Merkezinde bulunan tarihi Kaleiçi Yat Limanı'na kadar olan kıyı şeridinde Manavgat-Side'de bulunan Antik Side Yat Limanı dışında herhangi bir kıyı tesisi bulunmamaktadır. Çok

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sayıda günübirlik gezi teknesinin bulunduğu Manavgat Bölgesi'ndeki deniz araçlarının büyük bir çoğunluğu zorunlu olarak barınak olarak Manavgat Nehrini kullanmaktadır. Benzer şekilde Serik kıyılarında faaliyet gösteren yat ve gezi tekneleri Belek Acısu, Aksu/Kundu Bölgesi'nde faaliyet gösteren yat ve gezi tekneleri de Aksu Çayı'nı barınak olarak kullanmaktadır. Antalya İl Merkezinde ise iki yat limanı (Kaleiçi Yat Limanı ve Setur Antalya Marina) ve bir balıkçı barınağı (Çaltıcak Balıkçı Barınağı) mevcuttur. Faaliyet alanı Antalya Körfezi olan yat ve gezi tekneleri büyük oranda bu kıyı tesislerinde barınmaktadırlar. Antalya'nın batı kıyılarında bulunan önemli turizm merkezlerinden Kemer, Finike ve Demre ilçelerinde birer adet, Kaş İlçesi'nde üç adet yat limanı (Kaş Yat Limanı, Setur Kaş Marina ve Kalkan Yat Limanı) bulunmaktadır. Kemer ve Finike ilçeleri arasında kalan kıyılarda faaliyet gösteren yat ve gezi teknelerinin Çıralı ve Adrasan koylarında, Demre İlçesi ile Kaş ilçesi arasında kalan kıyılardaki yat ve gezi teknelerinin Kekova'da bulunan Üçağız İskelesi'nde barındıkları saptanmıştır.

Şekil 1. Yat ve günübirlik gezi teknelerinin barınak olarak kullandığı kıyı tesisleri (Yat limanı, Balkçı barınağı ve İskele) ve doğal barınma alanları (Nehir, çay ve koy)

2.2 Barınma noktalarının AKT (Atık Kabul Tesisi) Altyapıları

Gemilerden Atık Alınması ve Atıkların Kontrolü Yönetmeliği (2010), Denizcilik Atıkları Uygulaması Hakkında Genelge (ÇŞİB, 2022) ve 5216 Sayılı Büyükşehir Belediyesi Kanunu (2004) ile AKT'lerin kurulması, işletilmesi, alınan atıkların imhası ve gemi denetimleri gibi hususlar düzenlenmiştir. Söz konusu düzenlemeler gereği Antalya kıyılarındaki yat ve günübirlik gezi teknelerinin barınma alanlarında yapılan çalışmalarda tespit edilen AKT altyapılarına ilişkin veriler Tablo 1'de verilmiştir.

Antalya kıyılarındaki yat ve günübirlik gezi teknelerinin barınma noktalarından Gazipaşa Gold Marina, Belek Acısu, Çıralı ve Adrasan'da AKT bulunmadığı saptanmıştır. Yakın bir gelecekte faaliyete geçmesi beklenen Gazipaşa Gold Marina'da AKT'nin kurulacağı tahmin edilmektedir. Ancak, Belek/Acısu'da AKT altyapısının oluşturulmasına yönelik bir çalışma olduğuna ilişkin bilgi edinilememiştir. Çıralı ve Adrasan koylarında barınan yat ve gezi teknelerinin atıklarının ise atık alım gemisi tarafından alındığı saptanmıştır. Diğer barınma alanlarında ise MARPOL Ek I, IV ve V kapsamındaki atıklarının alımı için uygun altyapıların oluşturulduğu anlaşılmıştır.

Tablo 1. Antalya kıyılarındaki deniz araçları (yat ve günübirlik gezi teknesi) barınma yerlerinin kapasiteleri ve atık alım hizmetleri [MARPOL Ek I: Atık yağ ve sintine, Ek IV: Pis su, Ek V: Katı atık ve çöp]

	Liman/Barınak Adı	Kapastesi (Gemi sayısı)		Verilen atık alım hizmeti
İlçe	Hizmet verilen	Denizde	Karada	MARPOL Ek I, IV, V
Gazipaşa	Gazipaşa Gold Marina	200	50	-
Alanya	Alanya Yat Limanı	300	11	Ek I, IV, V
	Alanya Marina	287	160	Ek I, IV, V
Manavgat	Manavgat Nehri			Ek I, IV, V
	Antik Side Limanı	50	-	Ek I, IV, V
Serik	Belek/Acısu Çayı			-
Aksu	Kundu/Aksu Çayı			Ek I, IV, V
Muratpaşa	Kaleiçi Yat Limanı	65	-	Ek I, IV, V
Konyaaltı	Setur Antalya Marina	198	150	Ek I, IV, V
	Çaltıcak Balıkçı Barınağı	-	-	Ek I, IV, V
Kemer	Kemer G-Marin	230	140	Ek I, IV, V
	Çıralı			Ek I, IV, V
	Adrasan			Ek I, IV, V
Finike	Setur Finike Marina	320	150	Ek I, IV, V
Demre	Demre/Çayağzı Yat Limanı	400	300	Ek I, IV, V
	Kekova/Üçağız İskelesi	50	-	Ek I, IV, V
Kaş	Kaş Yat Limanı	100	-	Ek I, IV, V
	Setur Kaş Marina	450	150	Ek I, IV, V
	Kalkan Yat Limanı	60	-	Ek I, IV, V

AKT bulunan barınma yerlerinde MARPOL Ek I kapsamında alınan atıkların tamamına yakınını atık motor yağı ve sintine suyu oluşturmaktadır. Özellikle turizm sezonu öncesi ilkbahar aylarında yapılan motor bakımı esnasında ortaya çıkan (Dolgen, 2003) atık motor yağlarının bir kısmı AKT'lerine verilirken, bir kısmının da motor bakımı yapanlar tarafından geri dönüşüme verilmek üzere beraberlerinde götürüldüğü tespit edilmiştir. ATK'lere teslim edilen atık motor yağları önce mobil tanklara alınmakta, sonrada sabit tanklara aktarılmaktadır. Benzer şekilde sintine suları da önce mobil tanklara alınmakta daha sonra sabit tanklara transfer edilmektedir. Büyükşehir Belediyelerinin atık alım hizmeti verdikleri AKT'ler dışındaki tesislerde toplanan bu atıklar (atık motor yağı ve sintine) Gemilerden Atık Alınması ve Atıkların Kontrolü Yönetmeliği (2010) gereği, valilik temsilcisi başkanlığında; atık alım yükümlüsü, Maliye Bakanlığı taşra teşkilatı ve Emniyet/Jandarma teşkilatı temsilcileri, atık kabul tesisinin gümrüklü sahalarda bulunması durumunda; Gümrük ve Muhafaza Başmüdürlüğü temsilcilerinden oluşan komisyonun onayı ile geri dönüşüme ya da imha için lisanslı bertaraf firmalarına teslim edilmektedir. EK IV gereği alınması gereken pis sular ise AKT'lerde kurulu sistemler marifetiyle deniz araçlarından çekilerek kanalizasyon sistemine ya da sabit tanklara transfer edilmektedir. Sabit tanklarda toplana pis su atıkları ise işletmenin anlaşmalı olduğu vidanjör firmaları aracılığıyla atık su arıtma tesislerine transfer edilerek bertaraf edilmektedir.

MARPOL Ek V gereği, yat ve gezi teknelerinde biriken başta denizlerde uzun yıllar yok olmayan ve deniz yaşamına önemli zarar verebilen plastik, alüminyum ve diğer bazı metallerden imal edilen malzemeler (Battal, 2011) olmak üzere, kâğıt, cam, metal kutu, plastik atıklar ve çöplerin AKT'lere verilme zorunluluğu bulunmaktadır. Bu tür katı atıklar, deniz aracı çalışanları tarafından AKT'nce hazırlanmış olan konteynerlere bırakılmaktadır. Daha sonra konteynerlerde biriken katı atıklar bertaraf edilmek üzere, Belediye Temizlik ekiplerince çöp kamyonlarına boşaltılarak götürülmektedir. Ancak, yat ve gezi teknelerinde biriken katı atıkların tamamının karaya çıkarıldığını söylemek mümkün değildir. İtalya kıyılarında Galli vd. (2023) tarafından yapılan bir araştırmada deniz çöplerinin 10-15 mil deniz mili içindeki kıyı sularında toplandığını tespit etmişlerdir. Gedik ve Mugan-Ertugral (2019) tarafından yapılan çalışmada da, Türkiye kıyılarında artan kruz turizmi, yat işletmeciliği ve günübirlik tekneciliği nedeniyle özellikle Akdeniz kıyılarında denize bırakılan atıkların arttığı bildirilmektedir. Söz konusu araştırmaya göre denizdeki artan kirlilikten deniz yaşamı ve insan sağlığı olumsuz etkilenmiştir. Dolayısıyla, yat ve gezi teknelerinde ortaya çıkan katı atıkların bertarafı Antalya kıyıları için daha da önemli hale gelmektedir.

Barınma noktalarının alt yapıları ayrı ayrı değerlendirildiğinde; Alanya Yat Limanı'nda Alanya Belediyesi, Alanya Marina'da ise özel sektör tarafından işletilen birer adet AKT bulunmaktadır. Çok sayıda deniz aracı tarafından barınak olarak kullanılan ancak Balık ve Muslu (2016) tarafından yapılan çalışma da belirtildiği üzere yanaşma yeri, elektrik, su ve yakıt temini gibi hiçbir altyapısı bulunmayan Manavgat Nehri kıyısında bulunan AKT Manavgat Belediyesi tarafından işletilmektedir. Ek I, IV ve V kapsamı atıkların alımının yapıldığı tesisin yıpranmış olduğu gözlenmiştir. Pompa ve tankların yenilenmesinde yarar vardır. Manavgat'ta bulunan Antik Side Limanı'ndaki AKT'de Manavgat Belediyesi tarafından işletilmektedir. Saha çalışması esnasında tesis pompasının yerinde olmadığı, sökülerek götürüldüğü tespit edilmiştir. Muhtemelen arıza nedeniyle sökülmüş olduğu

tahmin edilen tesiste görevli personelin de yerinde olmadığı anlaşılmıştır. Pis su atığının, deniz araçlarının pompaları vasıtasıyla belirli aralıklarla kanalizasyon sistemine yerleştirilen gider kapaklarından kanalizasyon sistemine transfer edildiği belirlenmiştir. Her atık transferi sonrası, AKT sorumlusu aranılarak MKS'ne atık veri girişinin yapıldığı anlaşılmıştır. Bu uygulamanın devamlı getirilmesinin MKS'ne zarar vermesi kaçınılmaz olacaktır. Dolayısıyla, arızalanan pompanın yerine konularak aktif hale getirilmesi ve tesis görevlisinin çalışma saatlerinde görev başında olması sağlanmalıdır. Belek'de bulunan Acısu Irmağı'nda AKT bulunmamaktadır. Buradaki deniz araçlarının MKS'ne kayıtlı olup olmadıkları ve atıklarını nasıl yok ettikleri belirlenememiştir. Kundu'da bulunan Aksu Çayı kıyısında Botçular ve Tur Teknecileri Kooperatifi, Antalya Kaleiçi Yat Limanı'nda S.S. 200 No'lu Yelkenli Yat Motorlu Taşıyıcılar Kooperatifi, Çaltıcak Balıkçı Barınağı'nda da S.S. Yeni Liman Su Ürünleri Kooperatifi tarafından işletilen bir adet AKT bulunduğu tespit edilmiştir. Setur Antalya Marina, Kemer G-Marin ve Setur Finike Marinada da özel sektör tarafından işletilen birer adet AKT mevcuttur. Bu yat limanları ve balıkçı barınağındaki AKT'lerin tamamında MARPOL (73/78) EK I, IV ve V'de belirtilen atık alımlarının yapıldığı saptanmıştır. Çıralı ve Adrasan koylarında barınan deniz araçlarının ise atıklarını kendilerine en yakın olan Kemer G-Marin AKT'sine ya da S.S. Öz Adrasan, Olimpos, Çıralı Tekne ve Yatçılar Deniz Motorlu Taşıyıcılar Kooperatifi tarafından işletilmekte olan Atık Alım Gemisine verdikleri saptanmıştır. Atık alım gemisinde de MARPOL Ek I, IV ve V kapsamındaki atık alımlarının eksiksiz olarak uygulandığı belirlenmiştir. Demre İlçesi'nde bulunan Demre Yat Limanı'nda ve Kekova Üçağız İskelede S.S. Demre Deniz Motorlu Taşıyıcılar Kooperatifi tarafından işletilen birer AKT bulunmaktadır. İncaz (2022) tarafından da belirtildiği üzere elektrik, su, palamar gibi hizmetlerin eksiksiz olarak verildiği Kaş Yat Limanı ile Kalkan'da bulunan Yat Limanı'nda Kaş Belediyesi tarafından, Setur Kaş Marina'da da özel sektör tarafından işletilen birer adet AKT bulunduğu tespit edilmiştir. Diğer ATK'lerde olduğu gibi Demre, Kekova, Kaş ve Kalkan'da bulunan yat limanları ve iskelede de MARPOL Ek I, IV ve V gereklerine uygun hizmet verildiği saptanmıştır.

2.3 MKS (Mavi Kart Sistemi) Uygulamasında Karşılaşılan Sorunlar

Antalya kıyılarındaki AKT'ler arasında bazı yapısal farklılıklar bulunmakta ise de Antik Side Limanı dışındaki AKT'lerde MKS gereklerinin mevcut yasal mevzuata uygun olarak yerine getirildiği saptanmıştır. Ancak, sistemin, denizleri yat ve günübirlik gezi tekneleri kaynaklı kirleticilerden yeterince koruduğunu söylemek mümkün değildir. Bunun söylenebilmesi için hiç bir yat ve gezi teknesinin denize sıvı ya da katı atık bırakmadığından emin olmak gerekmektedir. Halbuki, sistemin uygulanma aşamasındaki sorunlar buna imkan vermemektedir. Çanak ve Baştuğ (2022) tarafından da belirtildiği üzere 2015 yılından itibaren kademeli geçiş uygulanan MKS sürekli bir gelişim içerisindedir. Yapılacak bilimsel araştırmalarla aksayan yönlerinin ayrıntılı olarak ortaya konmasına ve aksaklıklarına yönelik önerilerin getirilmesine ihtiyacı vardır. Antalya kıyılarında yapılan bu çalışmada da hem bölgedeki sistemin altyapısı hem de uygulanmasına ilişkin bazı eksiklikler tespit edilmiştir. Bu eksiklikleri aşağıdaki şekilde özetlemek mümkündür.

Çevre, Şehircilik ve İklim Değişikliği Bakanlığı'nın 9 Eylül 2022 tarihli Denizcilik Atıkları Uygulaması Hakkında Genelgeye (ÇŞİB, 2022) göre MKS'ye atık vermesi gereken gemilerden yolcu ve personel taşıma kapasitesi 12 kişiden az olanlar pis su atıklarını ve çöplerini 15 günde en az bir kere; 12 kişi ve daha fazla olanlar ise limandan ayrıldıktan sonra faaliyetlerini tamamladıktan sonra 10 gün içerisinde; 10 gün içerisinde tekrar sefere çıkmaları halinde ise sefer öncesi atıklarını AKT veya atık alma gemisine vermek zorundadırlar. Daha önceki uygulamada deniz araçlarından çekilen atık miktarlarının karta işlenme zorunluluğu bulunmaktaydı. Mevcut uygulamada ise sisteme veri girişi AKT görevlisi tarafından yapılmaktadır. Bunun yanısıra deniz araçları sahipleri ve çalışanlarıyla yapılan görüşmelerde AKT görevlisinin yerinde olmaması halinde bazı barınma noktalarında atık transferinin deniz aracı sahiplerinin veya çalışanlarının gerçekleştirdiklerini, sisteme atık veri girişinin de beyan üzerine AKT görevlisi tarafından yapıldığı ifade anlaşılmıştır. Bu da, sadece ücret tahsilatı yapılarak AKT'ne pis su verilmeden MKS'ne atık veri girişinin yapılması gibi sistemin amacıyla uyumlu olmayan usulsüz uygulamaların ortaya çıkmasına neden olabilir.

AKT'lerde, deniz araçlarından pis suyun transferinde kullanılan devrede bulunan sayaçların çalışıp çalışmadığının kontrolü yapılamamaktadır. Bu da, atık transferi konusunda tereddütlerin oluşmasına neden olmaktadır.

Daha çok motor bakımı esnasında ortaya çıkan ve AKT'lere verilmesi gereken MARPOL Ek I kapsamındaki atık motor yağlarının bir kısmının motor bakımı yapan şahıslar tarafından götürülmesinin yaygın bir uygulama olduğu saptanmıştır. Bu tür uygulamalara son verilmelidir.

Yat ve günübirlik gezi teknelerinde, aktivite tipleri ve yoğunluklarına göre değişen miktarlarda sintine suyu birikebilir. Makine dairesinde üretilen yakıt, yağ ve diğer toksik maddeler içeren sintine suyu (Carreño ve Lloret, 2021: 5) deniz ekosistemleri için oldukça kirletici özelliktedir. Ancak, yapılan saha çalışmaları esnasında AKT'lere sintine veren deniz aracı sayısının ve sintine verme sıklığının düşük olduğu anlaşılmıştır. Bu da deniz araçları tarafından sintinenin denize basılıyor olma ihtimalini güçlendirmektedir. Bu ihtimali, Akaltan ve Gökdemir (2018) tarafından Türkiye marinaları üzerine yapılan çalışmada 180 gün içerisinde komisyon kararı ile lisanslı bertaraf firmalarına gönderilmesi gereken tanklarda biriken atık yağ ve sintine suyu miktarlarının çok az olduğunu belirtiliyor olması da güçlendirmektedir. Bunun, atık transfer formuna sintine satırı eklenmek suretiyle engellenmesi mümkün olabilir. Şöyle ki, AKT görevlisi pis su transferi esnasında sintine kontrolünü de yaparak transfer

formuna işleyebilir. Böylelikle pis suyun yanısıra en büyük problemlerden biri olan sintinenin bertarafı ve takibi de sağlanmış olur.

SONUÇLAR VE ÖNERİLER

Antalya kıyılarında MKS'nin altyapısı ve uygulanmasında yaşanan sorunların araştırıldığı bu çalışmada, Antik Side Limanı dışındaki kıyı tesislerinde MARPOL 73/78 sözleşmesinin Ek I, IV ve V protokolleri kapsamındaki atıkların alımı için oluşturulan AKT'lerin önemli yapısal sorunlarının olmadığı anlaşılmıştır. Doğal barınma alanlarından Manavgat Nehri ve Kundu/Aksu Çayında AKT eksiz olarak faaliyet göstermekte iken Belek/Acısu'da AKT bulunmamaktadır. Çıralı ve Adrasan koylarını barınak olarak kullanan yat ve gezi tekneleri ise atıklarını atık toplama gemisine vermektedirler.

Ülkemizin önemli deniz turizmi merkezlerinden Manavgat kıyılarında yer alan Antik Side Limanı'ndaki AKT'nde pis su çekiminde kullanılan pompanın yerine olmadığı saptanmıştır. Söz konusu pompanın yerine konulması ve faaliyete geçirilmesi gerekmektedir.

Bazı AKT'lerde, görevli personelin tesiste bulunmadığı zamanlarda pis su atık transferinin deniz aracı sahipleri veya çalışanları tarafından yapıldığı saptanmıştır. AKT görevlilerinin mutlaka tesiste bulunmaları ve atık alımının görevliler tarafından gerçekleştirilmesi sağlanmalıdır. Böylece, yapılıp yapılmadığı şüpheli olan atıkların MKS'ne işlenmesi engellenmelidir.

Yat ve gezi teknelerinin bakımı esnasında ortaya çıkan atık motor yağları MARPOL 73/78 sözleşmesinin Ek I protokolü gereği AKT'lere verilmesi gerekirken bir kısmının verilmediği anlaşılmıştır. Bunun önlenebilmesi için yat ve gezi teknelerine yılda en az bir kere AKT'ye atık motor yağı verilmesi zorunluluğu getirilebilir.

Denize olası sintine suyu basılması, atık transfer formuna sintine satırı eklenmek suretiyle engellenebilir. Şöyle ki, AKT görevlisi pis su transferi esnasında sintine kontrolünü de yaparak transfer formuna işleyebilir. Böylelikle pis suyun yanısıra en büyük problemlerden biri olan sintinenin bertarafı ve takibi de sağlanmış olacaktır.

MKS'ne pis su miktarı girişi yapılmadığından denetimlerde tereddütler oluşabildiği belirlenmiştir. Bunun önlenmesi için atık transferi süresince pis su akışının gerçekleşme görüntüsünü kaydeden bir sistemin/belirtecin sisteme eklenmesi yararlı olacaktır.

Yat ve gezi teknelerinde ortaya çıkan katı atıkların genellikle AKT'lerde bulunan çöp konteynerlerine bırakıldıkları anlaşılmıştır. Ancak, denize atılan katı atık olup olmadığı, atılıyorsa ne kadarının denize atıldığı bilinmemektedir. Bu da araştırılması gereken bir önemli bir konudur.

Muslu (2018) tarafından tekne ve gemilerden kaynaklanan atık suların yönetimi için uygulanan MKS'nin altyapı eksiklikleri nedeniyle etkili bir çözüm sunamadığı, denizlerin korunması için bürokrasinin değil, işlevsel ve kapsamlı bir altyapının öncelikli olması gerektiğini ifade edilmesine karşın; Ergenç (2021) tarafından atık türlerine göre farklılık göstermekle birlikte AKT'lere verilen atıkların miktarının MKS uygulamasından sonra arttığı, kesilen cezaların ise azaldığı bildirilmektedir. İki araştırmada ifade edilen görüşlerden de anlaşılacağı üzere MKS'nin yat ve gezi teknesi kaynaklı kirliliği önlemedeki başarısı hakkında farklı görüşler bulunmaktadır. Alınan atıkların miktarları bilinmediği için ayrıntılı bir değerlendirme yapmak mümkün olmasa da gerek yapmış olduğumuz araştırmanın sonuçları gerekse gözlemlerimiz yat ve gezi teknelerinde biriken sıvı ve katı atıkların büyük bir kısmının AKT'lere verildiği yönündedir. Yapılan bu araştırmada tespit edilen sorunların giderilmesi MKS'nin başarısını olumlu etkileyecektir. Ayrıca, bu alanda yapılacak başka araştırmaların sonuçlarından yararlanılarak sistemin geliştirilmesine devam edilmelidir.

Çalışmanın Kısıtları:

Araştırma konusuyla ilgili bazı veriler, işletmeler tarafından kayıt zorunluluğu bulunmadığı için alınmadığından elde edilememiştir. Dolayısıyla konuyla ilgili değerlendirmeler somut veriler yerine soyut kavramlara göre yapılmıştır. Bu da araştırmanın gücünü kısıtlayan önemli bir husus olmuştur.

Gelecek Araştırmalar:

Konuyla ilgili gelecekte yapılacak araştırmalarda kullanılacak verilerin, belirlenecek uygun yöntemler kullanılarak saha çalışmalarını yürütecek araştırıcılar tarafından toplanmasını sağlayacak organizasyonun yapılmasında yarar vardır.

Etik Standartlara Uyum

Çıkar Çatışması

Yazar(lar), bu çalışmada herhangi bir çıkar çatışmasının bulunmadığını beyan eder. Eğer çıkar çatışması mevcut ise, bu durumun ayrıntıları ve nasıl çözüleceği, ıslak imzalı Çıkar Çatışması Beyan Formu ile birlikte belirtilmiş aynı şekilde bu form, makale süreç dosyasına eklenmiş ve her bir yazar tarafından ayrı ayrı imzalanmıştır.

Çıkar çatışması, yalnızca yazar(lar) arasında değil, aynı zamanda yazar(lar) ile üçüncü kişiler veya kurumlar arasındaki olası hukuki ve etik ilişkileri de kapsamalıdır.

Etik Kurul İzni

Bu çalışma için etik kurul iznine gerek yoktur. Buna ilişkin ıslak imzalı onam formu, makale süreç dosyasına eklenmiştir.

Finansal Destek
Finansal destek bulunmamaktadır.

Teşekkür
Teşekkür edilecek kişi veya kurum bulunmamaktadır.

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EXTENDED SUMMARY

The field studies of this study, which investigated the problems experienced in the Blue Card System (MKS) infrastructure and implementation process along the coasts of Antalya, were carried out between May and October (2024). In the field studies, mooring sites used by yachts and daily excursion boats were identified on the coastline from Antalya city center to the Mersin province border in the east and to the Muğla province border in the west, and the Waste Reception Facility (WRF) infrastructures established in accordance with the Annex I, IV and V protocols of the MARPOL convention were examined at the mooring sites and the problems experienced in the implementation of the MKS were tried to be determined.

In the research; It was determined that 14 coastal facilities (Gazipaşa Gold Marina, Alanya Marina, Alanya Marina, Ancient Side Harbor, Kaleiçi Marina, Setur Antalya Marina, Çaltıcak Fishing Shelter, Kemer G-Marin, Setur Finike Marina, Demre Çayağzı Marina, Kekova Üçağız Pier, Kaş Marina, Setur Kaş Marina and Kalkan Marina), 3 rivers (Manavgat River, Belek Acısu, Aksu Stream) and 2 bays (Çıralı and Adrasan) located on the Antalya coast were used as shelters by yachts and daily tour boats. It was determined that there was no coastal facility in Gazipaşa Gold Marina, which was recently completed and not yet put into operation, and that there was no replacement pump used for wastewater extraction in ATK located in Ancient Side Harbor. It was determined that wastewater transfer was done by yacht and tour boat pumps in this coastal facility. While AKTs operate without interruption in the natural sheltering areas of Manavgat River and Kundu/Aksu Stream, there is no AKT in Belek/Acısu. Yachts and daily excursion boats using Çıralı and Adrasan bays as shelters give their waste to the waste collection ship.

Waste collections within the scope of Annex I, IV and V protocols of MARPOL Convention are carried out completely in other sheltering points except Gazipaşa Gold Marina, Belek/Acısu and Ancient Side Harbor where there are some deficiencies and waste delivery entry is carried out by system officers without any problems. However, it has been determined that there are issues that may lead to water-abuse especially in MKS waste data entries. One of these problems is that the pump in AKT in Antique Side Port located on Manavgat coast, an important tourism center of our country, has been dismantled and waste water is drawn by the pumps of yachts and Daily excursion boats and waste data entry is not made by the officers based on the declarations of yacht and tour boat employees. In order to eliminate this problem, the pump used in waste water collection should be installed in its place and waste collection should definitely be carried out by the authorized personnel. Another important problem is that waste water waste transfer is occasionally carried out by the owners or employees of the sea vessel in some AKTs. It should be ensured that AKT officers are present at the facility during the time period when waste collection is made and that waste collection is carried out by the officers, thus preventing waste data entry to the MKS even though no waste transfer is made. Another problem detected at the sheltering points is that waste engine oils generated during the maintenance of yachts and Daily excursion boats should be given to AKTs according to the Annex I protocol of the MARPOL 73/78 convention, but some of them are taken by the technical staff performing engine maintenance. In order to prevent this practice, which creates weaknesses in the implementation of the system, it can be made mandatory for yachts and tour boats to give waste engine oil to the AKT at least once a year. It has been determined that there are problems in the monitoring of bilge formed in yachts and daily excursion boats in MKS. It is thought that this can be prevented by adding a bilge line to the waste transfer form. The AKT officer can also check the bilge during the transfer of waste water and record it in the transfer form. In this way, disposal and monitoring of bilge, which is one of the biggest problems in addition to waste water, will also be ensured. Another important problem of MKS is that it does not allow monitoring of whether wastewater transfer is taking place in AKTs. It would be useful to add a system/indicator to the system that records the image of the wastewater flow during waste transfer. It has been understood that solid waste generated on yachts and tour boats are generally left in garbage containers located in AKTs. However, it is not known whether solid waste is being thrown into the sea and if so, how much of it is being thrown into the sea. This is also an important issue that needs to be investigated.

Some studies conducted in Turkey indicate that MKS cannot provide an effective solution for the management of wastewater originating from yachts and pleasure boats due to infrastructural deficiencies, and that a functional and comprehensive infrastructure, not bureaucracy, should be the priority for the protection of the seas. In some studies, it is reported that the amount of waste given to AKTs increased after the implementation of MKS, while the fines imposed decreased, although they differ according to the types of waste. These views indicate that there are different views on the success of MKS in preventing pollution originating from yachts and daily excursion boats. The results of our research reveal that although the amount of waste collected could not be determined, a large portion of the liquid and solid waste accumulated in yachts and pleasure boats was given to AKTs. Eliminating the identified problems and taking the suggested measures will increase the success of MKS. There is a need to reveal the deficiencies of MKS through scientific research and to propose solutions. It is thought that the implementation of the suggestions presented in this study conducted along the coasts of Antalya will contribute to the development of the system. The development of the system should continue with other research to be conducted in this field.

Research Article

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Nature-Compatible Landscape Design Approaches for Large-Scale Areas: The Case of Muğla

Büyük Ölçekli Alanlar için Doğayla Uyumlu Peyzaj Tasarım Yaklaşımları: Muğla Örneği

Okan YELER[1]
Şevin BAYRAM[2]

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ABSTRACT:

The interaction between humans and nature, along with the utilization of natural spaces to meet their needs, has led to the development of spatial solutions that are both functional and environmentally compatible. In this context, landscape design, which seeks to create outdoor spaces that align with ecological characteristics while fulfilling functional and aesthetic requirements, has become a vital sub-discipline within landscape architecture. The landscape design process involves translating planning decisions into optimal spatial solutions. Nature-compatible landscape designs prioritize the preservation of natural areas and prevent environmental degradation by considering the ecological and natural characteristics of the landscape. These ecological designs, particularly crucial in urban areas, are increasingly applied to large urban spaces, open areas, urban green spaces, and protected zones. Integrating large natural areas with urban spaces through landscape design significantly benefits cities and their inhabitants. Based on this premise, this study proposes an approach to landscape design for large-scale areas, identifying land uses that are environmentally sustainable and minimally invasive. As part of the research, detailed landscape design proposals, including site plans and visual representations, were developed for a selected site in Muğla province. The study presents a nature-compatible landscape design model applied to a forested area within Muğla's borders.

KEYWORDS: *Nature Area, Ecology, Muğla, Landscape Design*

ÖZ:

İnsanların doğa ile etkileşimi ve ihtiyaçları doğrultusunda doğal alanları kullanması, onları bulunduğu çevreye ve doğaya uyumlu, ihtiyaçlarını gideren mekânsal çözümlemelere yönlendirmiştir. Bu doğrultuda hem fonksiyonel hem görsel nitelikteki ihtiyaçları tamamlayan, dış mekanda ekolojik özelliklere uyumlu tasarım önerileri geliştirmeyi hedefleyen peyzaj tasarımı, peyzaj mimarlığı altında yer alan önemli bir alt disiplin olmuştur. Peyzaj tasarım süreci planlamada alınan kararların en uygun biçimde mekânsal çözümlemeler olarak ortaya çıkarılmasıdır. Özellikle doğal alanların korunmasına ve tahribatın önlenmesine önem veren doğa ile uyumlu peyzaj tasarımları, peyzaj alanlarının ekolojik ve doğal özelliklerini göz önünde bulundurarak çözümler sunmaktadır. Kentsel alanlarda ihtiyaç duyulan bu doğa ile uyumlu, ekolojik tasarımlar günümüzde kent içlerinde yer alan büyük alanlarda, açık alanlarda, kentsel yeşil alanlarda veya korunan alanlarda peyzaj tasarımları ile geliştirilmektedir. Özellikle kent ile bağlantısı bulunan doğa ile bütünleşik büyük alanların peyzaj tasarımı ile geliştirilerek kullanıma açılması birçok noktada kente ve kullanıcılara katkı sağlayacaktır. Bu noktadan yola çıkılarak ortaya çıkarılan bu çalışmada, büyük alanlarda doğa ile uyumlu peyzaj tasarımlarının nasıl olması gerektiğini ve bu alanların tasarımında hangi kullanımları belirlemek gerektiği ile ilgili öneriler sunulmuştur. Araştırmanın amacı Muğla'nın Fethiye Yanıklar bölgesinde, doğa ile uyumlu peyzaj tasarımı uygulamaları yapılmasının bölgedeki ekolojik bozulmayı azaltarak, sürdürülebilir turizm potansiyelini artıracağı yönündeki etkileri ortaya

[1] Van Yuzuncu Yil University, okanyeler@yyu.edu.tr, ORCID: 0000-0002-0405-4829
[2] **Corresponding Author:** Van Yuzuncu Yil University, sevinbayram@yyu.edu.tr, ORCID: 0000-0001-5238-5887

çıkarmaktır. Çalışmada Muğla ili sınırlarında yer alan bir ormanlık alan üzerinde doğa ile uyumlu bir peyzaj tasarım proje örneği ortaya çıkarılmıştır.

Anahtar Kelimeler: *Doğal Alan, Ekoloji, Muğla, Peyzaj Tasarımı*

INTRODUCTION

It is known that throughout history, humans have interacted with their external environment and nature. This interaction has established a bridge between humans and their surroundings, defining humans as an inseparable whole from the environment they inhabit. Human existence depends on the continuity of nature, and the balance between the natural environment and humans has been equated with the balance of conservation and utilization (Emekçi, 2021). Particularly after the Industrial Revolution and the subsequent urbanization, the loss of natural areas within urban spaces and daily life caused urbanization to extend toward rural areas in the 20th century (Özgüner, 2003). The ever-increasing human population has further contributed to the destruction, degradation, and inability of the natural regions to renew themselves, resulting from interactions with nature (Aytis and Ozcam, 2010). Consequently, significant responsibilities fall upon nature- and environment-based disciplines. Among these disciplines, landscape architecture undertakes environmental planning and design efforts to protect and utilize nature appropriately. Within the sub-discipline of landscape design, ecological designs that are harmonious with nature, environmentally conscious, climate-sensitive, resilient, and sustainable have come to the forefront to raise environmental awareness.

Design is one of the activities that play a significant role in solving many existing problems today. The design approach has shown development across various disciplines. Particularly, design, which provides the ability to present possibilities to meet the requirements of a workload, implement complex thinking systems in real life, and take goal-oriented actions (Wang and Foley, 2021), is utilized in spatial and product-oriented disciplines such as architecture, urban planning, landscape architecture, interior design, industrial design, and graphic design. Landscape design, defined as a sub-discipline of landscape architecture, is a process where outdoor spaces and human environments are shaped and detailed within the framework of planning decisions. In this process, factors such as land use, size, scale, and users are considered, and uses are determined according to the needs of the area (Korkut et al., 2017). Landscape design is the final stage of landscape planning, producing user-centered functional, ecological, and visual solutions. To provide a high quality of life suitable for users in the physical environment, to improve and preserve the environment's functionality, and to manage user perceptions visually, comprehensive management of landscape design practices is essential (Kayar, 2023). Accurate and applicable spatial solutions related to the study area must be proposed to achieve solution-oriented results in landscape design.

Living in harmony with nature has shaped human activities and needs in this direction. As a result, landscape designs have come to the forefront of understanding the natural process (Makhzoumi and Pungetti, 1999). Since landscape designs are carried out in outdoor spaces, the design approach is directly influenced by nature. This highlights the necessity of considering natural conditions in landscape design. In landscape designs where natural conditions are considered, harmony with nature is also sought. In nature-focused design approaches within landscape design and planning, solutions can be produced by modeling nature and aligning with natural processes, structural features, and ecological characteristics (Yeler and Akdeniz, 2022). Especially in environmental approaches that are compatible with nature, the area to be designed must be compatible with existing local resources. As a result, adaptation to field conditions will be ensured, and low-cost practices that minimize natural resource consumption can be used to establish and maintain these areas. In this way, an ecological approach and harmony with nature are achieved in urban areas, and sustainability practices are contributed to (Birkeland, 2002; Cranz and Boland, 2003). Ecological landscape designs in urban areas affect user comfort, thermal comfort, air quality, and energy consumption in the given area. Therefore, nature-compatible and environmental design solutions must be increased in landscape design to ensure sustainability and maximize long-term efficiency from land use (Eliasson, 2000).

To achieve harmony with nature in landscape designs, parameters such as the climatic characteristics of the study area (air-humidity movement, water movement, shadow-sun movement, etc.), soil structure, site topography

(landform), structural elements, plant materials, available resources, ground coverings, and existing hydrological features are considered (Çakır, 2016; Korkut et al., 2017; Yeler and Akdeniz, 2022). These parameters ensure an area's design is compatible with its environment and nature while effectively preserving its natural uses. This also demonstrates that natural conditions directly influence the landscape design process.

Landscape designs proceed with nature-based solutions in mind. The discipline of landscape architecture, especially considering future scenarios that account for the increasing potential of human populations, develops design strategies in the form of solutions compatible with nature and addressing climate change. In this sense, it is evident that this discipline has the potential to produce solutions for such issues (IFLA, 2022; Acar and Yavuz, 2023). Landscape design applications, particularly in urban areas and other environments, sometimes positively and sometimes negatively contribute to interactions with nature. When these contributions result from nature-compatible approaches in landscape design, they positively impact the environment and humanity. Especially in urban areas, it is essential to use natural landscape elements and surfaces to reduce the impact of air temperature and urban heat islands. (Croce and Vettorato, 2021). In this context, nature-compatible landscape approaches play a critical role in environmental design approaches, meeting the environment's and humanity's needs.

This study presents sample landscape designs with a nature-compatible landscape design approach and suitable uses on a large-scale area, explicitly focusing on Yanıklar Sığla Forest in Fethiye, Muğla. The study aims to realize nature-compatible landscape designs to open large areas within nature for use. This study hypothesizes that landscape design practices in harmony with nature in the Fethiye Yanıklar region of Muğla will increase the sustainable tourism potential by reducing ecological degradation in the region. Accordingly, the sample design solutions developed in the study emphasize the use of appropriate structural materials in spatial analyses of the area, the creation of circulation systems and road networks compatible with the design of large regions and landforms, and the development of design proposals that do not cause damage to the natural environment and existing vegetation.

2. MATERIAL AND METHOD

2.1. Landscape design in large-scale areas: Muğla/Fethiye Yanıklar Area

In studies on large natural areas requiring comprehensive research in landscape design projects, parameters such as landform, vegetation, existing uses, usage needs, accessibility, and pedestrian circulation are essential. Accordingly, the intended use areas to be highlighted should be compatible with spatial characteristics and harmonious with nature. This study focuses on developing and emphasizing these ideas and proposes a landscape design project for a large area in Yanıklar, Fethiye, Muğla. The current terrain conditions and vegetation of the area were prioritized. The Sweetgum tree (Liquidambar orientalis), part of the area's natural vegetation, is emphasized. Considering the widespread uses of the Sweetgum tree, especially for medicinal purposes, the aim is to design a nature-compatible landscape project to highlight the importance of these trees to visitors and the local community and enable them to benefit from the advantages they provide.

- The following criteria were considered for the selected sample area in line with this project:
- The proximity of hotels for accommodation,
- It's close to Fethiye, a tourism center, and the airport,
- Its location bordering the sea,
- Adequate size of the area,
- Partial exposure to anthropogenic effects,
- The presence of a natural water source and its flow through the forest via a soil channel.

2.2. Description of study area

In landscape designs made in large areas, it is essential to analyze the current location of the selected area, its environmental effects, and the contributions it can provide to the user. In line with the analysis made for the existing

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area, suitable usage areas and design suggestions for landscape design can be developed. Parameters such as climatic data, land topography or form, hydrological structure, soil structure, and vegetation cover of the selected project areas are considered to realize a landscape design compatible with nature. In this direction, while determining the targeted study area, as a result of expert evaluations, the most suitable area that will contribute to and reflect the existing vegetation protection, promotion, and sustainability was tried to be determined. It aimed to realize a landscape design in this natural and large area to create a landscape design compatible with nature, introduce the existing vegetation to the local people and visitors, and emphasize its importance. The determined study area is a forested area comprising approximately 200 decares, mostly with sweet gum trees on the coast, water surfaces that need protection, and different natural vegetation covers and soil structures (Figure 1). This situation shows that the project to be designed in the area should be a work that is compatible with nature, does not harm the plants, and consists of natural materials.

Figure 1. Study Area

2.3. Field studies and area analysis

It is known that it is essential to protect natural areas located in rural or urban areas, host many living things, and pass them on to future generations. This study aimed to develop a correct planning and design strategy by performing existing analyses of the natural area. Investigations were carried out within the scope of the study in this project area, which has already suffered a lot of damage and is in danger of deterioration of the natural ecosystem. The research started from the route from the Yanıklar location of the study area to the coast. The area was determined to have uncontrolled entrances, and animal grazing and damage were caused. It was observed that the water surfaces, seashore, and roads passing around the study area were unprotected and open to damage that would disrupt the natural ecosystem. It was observed that the presence of vegetation specific to the region increased the ecological value of the area (Figure 2). The presence of settlements, such as hotels, etc., in the close vicinity of the study area also contributes to having an idea about the area in terms of usage intensity. In line with all this information, a general SWOT analysis of the area was carried out (Table 1).

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Figure 2. Study area existing trees.

Table 1. SWOT Analysis of the area.

STRENGTH	• The region has rich biodiversity, with a particularly high ecological value due to the presence of Liquidambar (Sweetgum) trees. • Presence of preserved natural landscapes. • Potential for ecotourism and nature-based sustainable tourism. • It is an area that will increase the quality of the region as a nature conservation area with its richness of biodiversity, flora and fauna of worldwide importance.
WEAKNESS	• Uncontrolled access and unregulated human activities that harm the area. • Damage to the natural balance due to animal grazing and other human-induced factors. • Insufficient protection of natural areas and lack of proper environmental regulations. • Lack of protection for coastal areas and water surfaces.
OPPORTUNITIES	• Since the region has Mediterranean climate characteristics, it is an area that can host visitors at any time of the year. • The fact that the area is home to many species and has an ecosystem is of great importance for the region's development. • The dense presence of sweetgum trees, a unique plant species in the region, makes the ecological structure of the area special.
THREATS	• Negative impacts of increasing human activities and tourism pressure on the ecosystem. • Risk of environmental degradation due to unplanned construction and infrastructure deficiencies. • Adverse effects of global climate change on the region's water resources and ecosystem. • In terms of wildlife, unconscious poaching threatens bird species in the area and damages trees.

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3. FINDINGS

The study area, which is located in the Special Environmental Protection Area and has unique ecological values and vegetation, has already suffered much damage and is facing the danger of deterioration of the natural ecosystem. The area should be used more appropriately to protect the damaged area more effectively in future processes. It is suggested that a landscape design arrangement be compatible with nature in the area. In this context, a landscape design approach has been developed with sustainable materials compatible with nature and wooden structures with minimum dimensions (only for mandatory needs) to protect the natural environment, promote the area to make it a tourism destination center, and inform the people living in the region and visiting the region under the scope of nature and health tourism with the name of Therapy Forest. In this direction, a site plan was created based on the analysis and examinations made for the study area first (Figure 3).

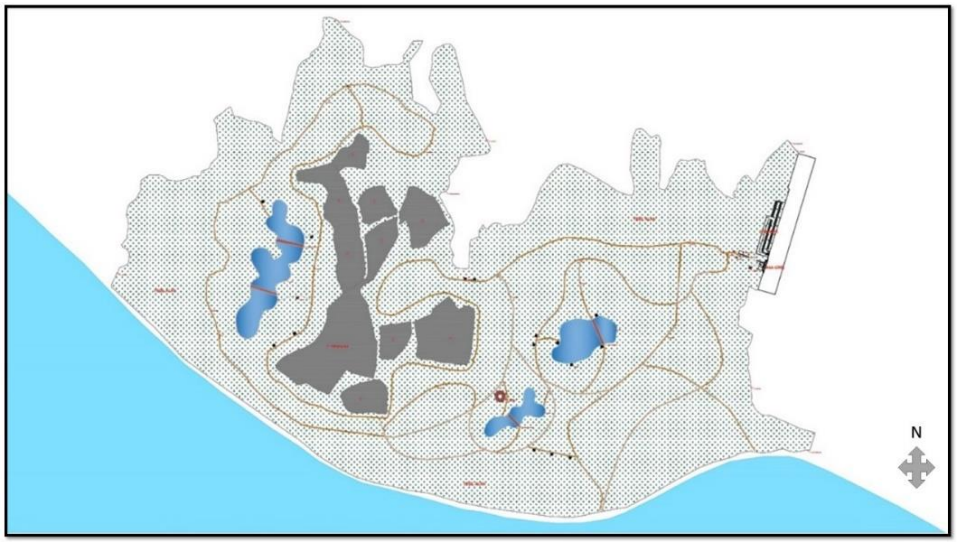

Figure 3. Proposed Site Plan for the Project Approach

As a result of the analyses and examinations conducted in the study area, the site's current conditions were considered, and a list of needs and uses was determined. Based on this, site plans and technical drawings were created, and the work was finalized with detailed visual presentations of landscape design. The identified list of needs includes:

- Entrance Gate
- Welcome Center / Information Area
- Security
- Parking Area
- Snack Bar & Restrooms
- Pavilions and Pergolas
- Bicycle / Electric Vehicle Rental Point
- Pedestrian / Bicycle / Electric Vehicle Pathways
- Site Boundary / Enclosure
- Surveillance Cameras
- Tree Observation Tower
- Directional, Informative, and Warning Signs

In the proposed approach for the study area, the region was secured by establishing an enclosure starting from the eastern side of the area and covering all parts down to the shoreline, including the coastal boundary. The lack of protection for the area exposes it to damage that could disrupt the natural ecosystem. Therefore, surveillance

cameras along the boundary ensure the area is monitored 24/7. In addition to securing the region with an enclosure wall, a security cabin at the gate and parking entrance in the northeastern area were included in the design.
A single entrance gate and its model are located in the northeastern section of the site. The gate was designed as a single-entry point for the entire area, featuring a unique design reflecting the therapeutic forest concept. It was constructed using nature-friendly materials such as wood and natural stones. A parking area with controlled access was planned next to the entrance. The parking location was chosen to cover a part of the site with the fewest trees, minimizing damage to the existing vegetation.

Immediately after the entrance, a Welcome Center was positioned to avoid creating structural impact or dominance within the area. Slightly further ahead but still close to the entrance, one snack bar and one restroom were planned. Adjacent to these, wooden platforms for electric vehicles and bicycle rental points were proposed. All structures within the area were designed using natural wood, ensuring environmental harmony and minimal interference with the natural landscape.

The site includes a Tree Observation Tower to highlight and promote the existing vegetation. Additionally, pavilions and informational, directional, and warning signs were strategically placed throughout the area. To enhance harmony with nature, wooden bridges, designed to align with the natural environment, were constructed over water surfaces integrated into the site.

Entrance Gate

A defining and introductory entrance gate design has been considered at the top of the list of needs for the study area. In line with this need, a nature-compatible entrance gate with a landscape design has been designed at the area entrance. Natural stone and wood building materials were used for the gate. The vertical water features on both the right and left sides of the entrance gate evoke a natural living environment, both because they are nature-based and due to the calming effect of the water (Figure 4).

Figure 4. Model images designed for the Entrance Gate

Welcome Center / Information Area

The Welcome Center, one of the essential structures in the list of needs for the study area, has been designed to introduce the area and inform visitors. Inside the Welcome Center is a reception desk providing information about the area, a display to introduce the local vegetation and unique souvenirs for visitors. Additional facilities have been included to complement the needs within the center, such as informational brochures, panels, and signs. A model of a Tree Observation Tower, the area's natural vegetation, has also been placed inside to allow visitors to closely touch and observe the tree.

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The structural elements of the Welcome Center, the materials used, and the interior design have been selected based on materials that harmonize with nature without disturbing the natural integrity of the site. In the interior of the Welcome Center, wood materials have been used for both vertical and horizontal elements and in the choice of furnishings. Additionally, an interior that aligns with nature has been created by placing a model of the Liquidamber tree inside (Figure 5).

Figure 5. Welcome Center Images

Security

A parking area and a security hut are next to the entrance gate. In the selection of the locations of these structures, care was taken not to damage the existing vegetation. Like other structural elements designed in the area, the structures were created with materials compatible with nature and integrated into the area in this way (Figure 6). The security hut is planned so that at least two people can control the movement inside. At the same time, a small area has been created inside for eating and drinking needs. All the materials used on the exterior are preferred in a way that does not disturb the nature of the existing workspace.

Figure 6. Security Images

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Parking Area

To the right of the entrance gate, a security checkpoint is located, and for the arriving guests, there is a parking area measuring 2.5 m * 5 m, with space for 200 vehicles and six accessible parking spots. Guests who enter through security and park their cars can directly access the area from the parking lot. A sufficient area was considered for the parking lot without considering a large hard ground area. In this way, the destruction of the existing green area was prevented, and the vegetation was preserved. The parking area has been designed in an appropriate location without damaging the existing vegetation (Figure 7).

Figure 7. Parking Area Images

Snack Bar & Restrooms

A 12 m² Snack Bar has been designed near the entrance area. The building material for the snack bar is treated as raw pine wood, which ensures natural harmony within the study area. Additionally, a restroom with an area of 25 m² has been designed close to the entrance and the snack bar. The building material for the restroom is also wood, ensuring natural harmony with the area, just like the snack bar. Inside the restroom are separate sections for two males, two females, and one disabled user. The snack bar and restroom structures have been designed to match the area's natural environment regarding structural integrity, material, and size (Figure 8).

Figure 8. Snack Bar & Restrooms Images

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Pavilions and Pergolas

A total of 40 gazebos have been placed along the walking paths in the area. Two different types of gazebos have been used. The first gazebo is built on a 25 m² concrete floor and consists of 7 seven wooden profiles arranged in a 10x10 layout. The second gazebo, measuring 9 m², is made of iron profiles with wood. Both gazebos are supported by vines creating, which create a canopy. Supported by green cover, pergolas and pergolas both aesthetically display an image integrated with nature and functionally benefit users by creating a shaded area. At the same time, natural solid wood material was used in the seating units and tables used in these pergolas in harmony with the exterior facade and floor material. In this way, a holistic design approach was focused on entirely natural materials. Thanks to this design approach, the use of green areas has also been reduced. Both gazebos' materials and plant elements contribute to the design's harmony with nature (Figure 9).

Figure 9. Pavilions and Pergolas Images

Bicycle / Electric Vehicle Rental Point

The circulation system for the entire area, starting from the entrance, is provided by a wooden path. The designed path is 3 meters wide and is intended to be a multipurpose route. Users can access and explore the area on foot, while the path allows for cycling and electric vehicle use. For this reason, both bicycle and electric vehicle rental stations have been placed at the area entrance. When considering these points, the scale of the existing area was taken into account, and in line with the need, vast areas were not preferred, and hard ground and structural elements were saved. At the same time, structurally costly and artificial materials were avoided. The electric vehicles used were also selected from models that would not harm the environment, and paths for bicycles were designed so as not to destroy the vegetation and the existing area. The structural elements and furnishings designed for these stations have been selected and created harmoniously with the area and nature (Figure 10).

Figure 10. Bicycle / Electric Vehicle Rental Point Images

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Pedestrian / Bicycle / Electric Vehicle Pathways

1.70-meter-wide wooden paths provide circulation throughout the entire area; the wooden path is 3.40 meters wide at the entrance. In the Therapy Forest, due to the trees' extensive and spreading roots, the area's circulation line has been designed as one way to avoid damaging the tree roots. To ensure compatibility with the natural environment and prevent pressure on the roots, "Treated Wood" has been used as the material. As a result, the circulation paths, which do not cover the entire area, have been designed in harmony with nature and natural materials (Figure 11).

Figure 11. Pedestrian / Bicycle / Electric Vehicle Pathways Images

Site Boundary / Enclosure

A boundary element created with enclosures has been considered to prevent entry and exit from surrounding parcels at the outer boundaries of the area. In this regard, an iron panel fence has been used to define the area's boundary. A rope fence supported by wooden posts has been used around all the wooden paths, providing circulation within the region (Figure 12).

Figure 12. Site Boundary / Enclosure Images

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Surveillance Cameras

360-degree rotating security cameras, which can be monitored from a security booth 24/7, have been placed within the area to ensure the area's security. These security cameras are positioned on the iron boundary enclosures surrounding the area and on poles at specific points within the area.

Figure 13. Surveillance Cameras Images

Tree Observation Tower

A watchtower has been designed with sparse vegetation within the area to highlight and promote natural vegetation. This 30-meter tall, five-layer observation tower allows for a bird's-eye view of the trees and the area. The structural materials used in the tower's construction are made of wood, which is in harmony with all the other structural elements in the area. The tower's five-layer spiral form represents nature and is designed to blend with the natural structure of the area. This watchtower is a focal point for visitors while providing a space for them to take photographs (Figure 14).

Figure 14. Tree Observation Tower Images

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Directional, Informative, and Warning Signs

Due to the size of the 200-decare working area, directional and informative signs have been placed to provide users with proper access. In this regard, signs directing visitors to key areas and warning signs have been positioned throughout the region. These signs are placed appropriately within the existing ecosystem. Formally, they are designed in a way that does not harm the wildlife in the area and are shaped to prevent damage to living creatures such as birds. At the same time, the presence of signs introducing the area contributed to creating an efficient landscape area by providing easy circulation and user accessibility—80 directional signs and area maps across the working area (Figure 15).

Figure 15. Directional, Informative, and Warning Signs Images

CONCLUSION

The development of landscape projects in harmony with nature offers excellent benefits for the protection and sustainability of ecosystems. These projects support the maintenance of natural habitats and biodiversity, helping to protect local flora and fauna species. It also ensures environmental balance by reducing soil erosion and protecting water resources (Elliason,2000). Increasing green spaces improves air quality and reduces the heat island effect in cities. Landscaping in harmony with nature allows people to interact more with nature, positively affecting mental and physical health. They also offer aesthetic and recreational values, improve the quality of life of communities, and promote environmental awareness. Landscape projects harmonizing with nature are essential to support environmental and social sustainability.

The Yanıklar region was studied in the Fethiye district of Muğla, home to many liquidamber trees and other flora species in an extensive 200-hectare working area. Based on all the inspections, research, and analyses conducted, it was observed that the region has been subjected to significant degradation over time. To protect, improve, and promote this area, which hosts many ecological elements, a landscape design project has been developed in alignment with the principles of nature conservation and sustainable use, aiming to transform the area into a nature and health tourism center recognized nationally and internationally.

The project approach initially focuses on areas within the site that have been impacted by human pressure and various environmental factors, leading to degradation. A few small, elevated, demountable wooden structures have been proposed where the ground primarily comprises hard surfaces and barren land with little vegetation. These structures, which will not harm the area, include an entrance section, parking lot, and wooden walkways to facilitate circulation within the forest based on on-site measurements and the suggested pedestrian path routes.

A welcome center has been designed for visitors to the area, but no access points other than the designated pedestrian paths have been included to maintain the natural integrity of the site. Along the pathways, seating pavilions made entirely of wood have been placed. Additionally, a wooden observation tower has been designed to provide visitors with an overhead view of the Sığla trees without causing ground disturbance.

In conclusion, the project's primary goal is to protect the area, take measures against further degradation, and promote the Sığla tree, which has been scientifically proven to have significant health benefits and contribute to its introduction into tourism. Landscape arrangements that are compatible with nature have been suggested for the site. It is believed that urgent intervention is required to preserve the region and ensure its transfer to future generations.

Additionally, this project provides significant insights not only in terms of ecological conservation but also in environmental policies and community participation. To ensure sustainable protection of the region, strong collaboration must be established among local governments, non-governmental organizations, and academic circles. Environmental policies should not only focus on conservation but also adopt an inclusive approach that actively involves the community in the process. In this context, raising awareness among local residents and visitors is of great importance. Awareness of the region's ecological values can be increased through educational programs, nature walks, ecological tours, and workshops.

To encourage community participation, volunteer initiatives, sustainable tourism practices, and eco-friendly economic models should be developed, ensuring the active involvement of local communities in the project. In this way, the region will not only be preserved but also evaluated in a socially and economically sustainable manner. Such approaches will provide long-term and lasting solutions in line with nature conservation and sustainable development goals.

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Use of Recyclable Waste As Acoustic Material For Indoor Applications

İç Mekân Uygulamaları İçin Geri Dönüştürülebilir Atıkların Akustik Malzeme Olarak Kullanımı

Umur ÖZBEK[1]

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ABSTRACT

The construction sector is characterized by an incessant demand for new materials, resulting in the continuous consumption of natural resources and exacerbating environmental degradation. This study aims to innovate within this context by developing a novel acoustic material through the strategic reuse of waste generated from construction and demolition activities. Specifically, brick waste serves as the primary constituent in the formulation of this new composite material. To enhance its acoustic properties, agricultural by-products, particularly paddy husks, are incorporated to introduce a porous structure, which is hypothesized to significantly augment the material's sound absorption capabilities. The overarching objective is to achieve a sound absorption coefficient that surpasses that of traditional brick materials, thereby offering a more effective solution for acoustic insulation in construction applications. This research is grounded in rigorous laboratory experimentation, wherein samples produced in two distinct thicknesses are meticulously evaluated using an impedance tube to ascertain their acoustic performance under controlled conditions. The findings of this study are anticipated to not only contribute to sustainable building practices but also to facilitate the reduction of waste in the construction industry, thereby fostering a more circular economy.

Keywords: Building and Demolition Waste, Acoustic Materials, Sound Absorption Coefficients, Brick Waste, Rice Husk

ÖZ

İnşaat sektörü, doğal kaynakların sürekli tüketilmesine ve çevresel bozulmanın şiddetlenmesine neden olan yeni malzemelere yönelik sürekli bir talep ile karakterize edilmektedir. Bu çalışma, inşaat ve yıkım faaliyetlerinden kaynaklanan atıkların stratejik olarak yeniden kullanımı yoluyla yeni bir akustik malzeme geliştirerek bu bağlamda yenilik yapmayı amaçlamaktadır. Özellikle tuğla atıkları bu yeni kompozit malzemenin formülasyonunda birincil bileşen olarak görev yapmaktadır. Akustik özelliklerini geliştirmek için tarımsal yan ürünler, özellikle de çeltik kabukları, malzemenin ses yutma kapasitesini önemli ölçüde artıracağı varsayılan gözenekli bir yapı oluşturmak üzere bir araya getirilmiştir. Genel amaç, geleneksel tuğla malzemelerini geride bırakan bir ses yutma katsayısı elde etmek ve böylece inşaat uygulamalarında akustik yalıtım için daha etkili bir çözüm sunmaktır. Bu araştırma, iki farklı kalınlıkta üretilen numunelerin kontrollü koşullar altında akustik performanslarını tespit etmek için bir empedans tüpü kullanılarak titizlikle değerlendirildiği kapsamlı laboratuvar deneylerine dayanmaktadır. Bu çalışmanın bulgularının yalnızca sürdürülebilir bina uygulamalarına katkıda bulunması değil, aynı zamanda inşaat sektöründe atıkların azaltılmasını kolaylaştırması ve böylece daha döngüsel bir ekonomiyi teşvik etmesi beklenmektedir.

Anahtar Kelimeler: Akustik Malzeme, Çeltik Kabuğu, İnşaat ve Yıkım Atıkları, Ses Yutma Katsayısı, Tuğla Atıklar.

[1] **Corresponding Author:** A Haliç University, Istanbul, umurozbek@halic.edu.tr, 0000-0002-1145-5372

INTRODUCTION

Natural resources are gradually decreasing due to the direct proportional increase in world population and consumption. Therefore, making existing wastes reusable through recycling is very important to protect natural resources by reducing the consumption of natural materials.

Materials considered as waste and suitable for recycling vary from region to region and country to country. The term 'waste' in this study refers specifically to construction and demolition waste, which includes brick waste, concrete, and other building materials that are discarded during construction activities or after the demolition of buildings. These wastes, often considered inert or unusable, are evaluated for their potential to be transformed into value-added materials through recycling and innovative applications.

Brick waste has been extensively studied in the context of sustainable construction materials. Gomes and De Brito (2009) highlighted the mechanical recycling potential of brick waste, emphasizing its application as a substitute for natural aggregates in concrete. Similarly, Silva, De Brito, and Dhir (2014) reviewed the reuse of ceramic waste, including bricks, in construction, demonstrating its viability in various structural and non-structural applications. These studies suggest that brick waste, often considered unusable, can be transformed into value-added materials with proper treatment and integration.

In terms of sound insulation, the utilization of porous materials has been shown to significantly improve acoustic performance. According to Berardi and Iannace (2015), recycled and natural materials with high porosity, such as agricultural by-products, exhibit excellent sound absorption properties. Specifically, rice husks have gained attention as an agricultural waste with unique characteristics. Gupta and Kua (2016) demonstrated that rice husk ash enhances the acoustic and thermal insulation of construction materials, making it a sustainable alternative in composite material development.

The integration of brick waste and agricultural by-products not only addresses environmental concerns but also aligns with global efforts toward circular economy practices. Studies by Torgal et al. (2011) emphasize the importance of utilizing local, abundant wastes to minimize ecological footprints and enhance material properties.

Waste diversity provides information about the climate, economy, life and consumption of the region. In a region that makes a living through agriculture, there are agricultural wastes, and in industrial areas, there are industrial and even hazardous wastes.

Acoustic comfort is one of the most important indoor comfort conditions. Sounds are a constant part of daily life. While listening to music and other pleasant sounds gives pleasure to the user, understanding through speaking and providing some of the methods of warning against dangers through sounds emphasize the technical and comfort importance of acoustic values. Unwanted sounds are called noise. Short and long-term exposure to noise causes different negative effects on human health. The ideal background noise levels that should be provided for spaces with different functions have been determined by academic studies and regulations. Failure to achieve the desired noise levels negatively affects the acoustic comfort conditions in the space.

There are many criteria that affect acoustic comfort conditions in a closed space, other than background noise. One of the most important criteria to be considered in evaluating the acoustic comfort conditions of indoor spaces is to ensure optimum reverberation time. After the active sound source in a closed space is turned off, the time it takes for the sound level in the space to decrease by 60 dB[2] (decrease by one millionth of the energy) is called reverberation time. The materials used on the interior surfaces of the space, furniture and the number of people play an active role in determining the reverberation time in a closed space. The interior materials to be used to ensure acoustic comfort conditions must be efficient and useful. At the same time, the materials used should be of a type that will not pose a risk to human health indoors over time.

[2] Decibel (dB) is a logarithmic unit used to measure sound intensity.

The objective of this study is to develop an acoustic material from construction and demolition waste, particularly brick waste, combined with agricultural by-products. The scope of the study includes laboratory experiments evaluating acoustic properties under controlled conditions. The methodology involves sample preparation with varying compositions and thicknesses, followed by testing using the impedance tube method.

1. Waste and Recycling Concepts

All kinds of substances that remain because of production, consumption, or elimination activities, are unwanted and are intended to be removed, are called waste. Waste and garbage are two different concepts that should not be confused. Garbage is the name given to all residues/materials that have lost their function, are free of reusable substances and cannot be recycled. Waste is all the materials that can be recycled and must be separated and recycled.

1.1 Waste Types

The need for waste management is gaining importance today due to the continuous increase in pollution caused by waste and the resulting increase in environmental risks, the rapid decrease in natural resources, economic and other reasons (Dönmez & Türker, 2017).

Wastes are classified into many types and are subjected to various recycling processes according to their types. After the recycling process, it can be used in different areas. After recycling, some wastes can be reused as materials with the same properties, while in some wastes, the materials resulting from the recycling process have different functions and properties.

1.1.1 Construction and Demolition Waste

Before starting the construction of a building, the soil resulting from the excavation and leveling works carried out to organize the land in the area where the building will be built is called excavation soil (Yarımçam & Parlak Biçer, 2020). The waste generated during the construction of roads, infrastructure and superstructures is called construction waste. Wastes resulting from the repair, renovation, renewal, demolition of residences, buildings, bridges, roads and similar infrastructure and superstructures or as a result of a natural disaster are also defined as demolition waste.

Although the accelerations in the construction sector cause a directly proportional increase in waste production, it also brings with it the problems of waste polluting nature more and taking up more space. This sector's acceleration in Turkey in the 2000s continues to grow, although it pauses from time to time.

The growth in the construction sector and the problems it brings create a necessary awareness for the solution of these problems (Craighill, 2002). Waste regulations issued, determination of compulsory dumping sites, R&D studies on materials that pollute nature less, and also the reuse of materials used during the construction phase in another building construction or in a different sector after the demolition of the building are among the measures taken to solve and slow down the problems.

An existing structure may be demolished for different reasons. Construction and excavation wastes are generated after demolition. The amount, type and diversity of waste to be generated varies depending on the size of the demolished building, its location, carrier system, construction method and type of building group.

A construction material goes through the stages of being extracted from the source, transported to the processing center or factory, processed, and turned into a product, transported to the site, used at the construction site, demolished, decomposed and recycled.

It is planned to use construction and demolition waste in the new composite material samples to be produced.

1.1.2 Evaluation of Construction and Demolition Waste

It is possible to reuse concrete waste by recycling or without further processing. It is possible to crush concrete waste without any further processing and use it in road construction, as asphalt filler and as a sound barrier. They can also

be reused in concrete containing recycled concrete aggregate after undergoing some processes. In these concretes, recycled concrete aggregates obtained and processed as waste are used instead of natural aggregates (Hendriks & Pietersen, 2000).

•Masonry Waste (Bricks, Ceramics, Stones)

Considering the current research, masonry wastes, like concrete wastes, can be used as aggregates in concretes using recycled aggregates. The definition of masonry waste is used for wastes such as bricks, ceramics, and stones.

•Metal Waste

Metal waste can be separated in detail and used directly, or it can be melted and reused in many different sectors. Metal wastes are first subjected to physical grinding in facilities. After this process, they are melted at high temperatures and poured into molds. Then, the metal coming out of the molds is pressed to the desired thickness.

•Wood Waste

Damaged wood waste can be used in the production of cardboard and paper, as well as in the production of wood-based panels, MDF, chipboard and similar using different processes and binders. In addition, some undamaged wood waste can be directly reused elsewhere.

•Glass Waste

It is very difficult to rescue glass from a demolition site without breaking it. However, in cases where uncontaminated glass can be obtained, it is possible to reuse the resulting glass waste in glass production (Hendriks & Pietersen, 2000).

•Insulation Materials Waste

It is possible to use insulation materials such as glass wool and mineral wool in the production of new glass wool and mineral wool materials after they are crushed and sieved.

If EPS(Expanded Polystyrene) sheets are not damaged, they can be reused directly or they can be used in the production of a new sheet by undergoing heat treatment (Hendriks & Pietersen, 2000).

•PVC (Polyvinyl Chloride) Waste

Recycling PVC waste can be easier than other wastes. It can be easily used in the production of a new PVC component by turning it into granules or powder through mechanical separation, grinding and other processes (Aksel Çiçekçi, 2020).

•Plasterboards

Plasterboards are a widely used material for walls and ceilings. After the plasterboards are removed from the place of use, the cardboard on the panelboard can be used in paper production. Additionally, gypsum panels can be used again in the production of gypsum panels.

2. Production and Measurement of New Composite Material

Recycling is becoming more important day by day. The reason for this is that the rapidly increasing consumption of natural resources poses major problems for the future. The first problem is that the danger of depletion of natural resources is inevitable. The second problem is that waste generated as a result of consumption accumulates and pollutes nature. Recycling and reusing existing waste are very important to protect natural resources by reducing consumption and to prevent further pollution of nature.

One of the sectors that produces the most waste is the construction industry. In the construction industry, natural materials such as wood and clay and petroleum and plastic-based synthetic-artificial building materials can be used.

Waste is generated during the construction and demolition of a building. The resulting waste consists of wastes such as concrete shards, brick shards, ceramic shards, metal pieces, wooden pieces, glass, insulation materials, PVC, and plaster plates. Some of these wastes can be reused, while some of them are stored in dump sites as useless waste and pollute the nature. It is very important to evaluate these wastes that are abandoned without being used. Based on this idea, the idea was to produce a new acoustic material from construction and demolition waste by recycling method and to evaluate these wastes.

As a result of the research, brick waste was selected among the wastes examined. The evaluation of these wastes as inert and limited reusable wastes after the construction and demolition processes played an important role in the selection. Within the scope of the study with brick wastes, rice husks were used to increase the porosity of newly produced samples. Rice husks were selected for this study primarily due to their unique physical and chemical properties, which are highly conducive to creating porous structures in composite materials. When subjected to high temperatures during the firing process, the organic content of rice husks burns off, leaving behind voids within the material matrix. This phenomenon significantly increases the porosity of the composite, which is directly correlated with improved sound absorption properties, as higher porosity enables better dissipation of sound energy within the material.

The choice of rice husks is supported by existing literature. For instance, studies by Jamil, Kaish, Alam, and Islam (2013) and Torgal, Jalali, Faria, and Henriques (2011) have highlighted the potential of agricultural by-products, including rice husks, in enhancing the functional properties of construction materials. Rice husks contain a high proportion of organic compounds such as cellulose and lignin, which combust during firing, leading to the formation of interconnected voids. This process not only improves the acoustic performance but also contributes to the lightweight nature of the material, a desirable characteristic for acoustic panels (Gupta & Kua, 2016).

2.1 Production of Samples

Samples with 3cm and 5cm thicknesses were produced to examine the differences that thickness may have on the sound absorption coefficients of the new material produced. The mixture for the composite material consisted of 50% brick waste, 49,75% clay as a binder, and 0,25% rice husks by weight. The samples were fired at 840°C, and their porosity and acoustic properties were subsequently tested.

In the samples produced, brick waste was used as the main material and clay was used as a binder. The code names, content, thickness and firing temperatures of the samples examined within the scope of the study are shown in Table 1.

Table 1. Characteristics of the Samples Examined Within the Scope of the Study (Özbek, 2022).

Sample Name	Thickness	Firing Temperature
840C3	3cm	840 °C
840C5	5cm	840 °C

After the planning, the production of sample mixtures started. Mixtures containing rice husks are shown in Figure 1.

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Fig. 1. Mixture Containing Produced Paddy Husk (Özbek, 2022).

In the next stage, the mixtures were thrown into the vacuum press machine, the air in the material mixture was sucked out and the samples were started to be shaped into cylinders by extrusion method with the help of a mold at the exit of the machine. Extrusion method is a production process in which a material is pushed through a mold in the desired cross-section and the material is compressed and forced to come out by taking the shape of the mold at the exit end. The sample material is first poured into the chamber of the machine. The air in the poured sample is sucked by vacuum and continues to move inside the cylinder. At the end of the cylinder, there is a mold with openings in the cross-section desired to be produced. When the material moving in the cylinder reaches the mold, it gets compressed and comes out, taking the shape of the mold.

After the samples were produced, they were placed in the drying oven to remove the water they contained. After the drying process, the samples were fired at 840°C. As a result of this process, the samples reached their final state. The final state of the samples is seen in Figure 2.

Fig. 2. Final State of the Samples (Özbek, 2022).

2.2 Sound Absorption Coefficient Measurement Method

Measurements of sound absorption coefficients of the samples were made with an impedance tube within the scope of TS EN ISO 10534-23 standard. The parts that make up the impedance tube are as follows.

• Speaker unit,

• Small diameter measuring tube used in high frequency measurements, into which two microphones can be placed,

• Sample holder piston that ensures correct samples are placed into the tube.

The impedance tube assembly used in the measurements is seen in Figure 3.

Fig. 3. Impedance Tube Assembly Used in Measurements (Özbek, 2022).

Sound absorption coefficient results were carried out with a small tube arrangement, and the measurements focused on the results in the 1/3 octave band between 500 Hz and 6.4 kHz. Before starting the measurements of the samples, calibration was performed to increase the sensitivity of the device. The microphones on the device were placed in their places, and measurements were made through the software on the computer connected to the device. The results of the measurements were obtained as an Excel table at the end of the procedures.

2.3 Sound Absorption Coefficient Measurements

After the sample production was carried out, sound absorption coefficient measurements were carried out using the impedance tube method. Before the measurements, a calibration process was performed on the impedance tube system. The gaps around the samples placed in the impedance tube were sealed with a thin layer of play dough to ensure sealing. In order to avoid errors in the measurements, the measurement was repeated 5 times for each sample. In each measurement, the sample was removed from the impedance tube and rotated to create a change in the surface angle. Then, the average of the 5 measurement results obtained for each sample was taken. As a result of the measurements, sound absorption coefficients in the range of 500 Hertz (Hz) - 6400 Hertz (Hz) in the 1/3 octave band were obtained. The obtained sound absorption coefficient values are shown in the figures below.

[3] TS EN ISO 10534-2: Turkish Standards European Norm International Organization for Standardization 10534-2 is a standard method for measuring sound absorption coefficients using an impedance tube.

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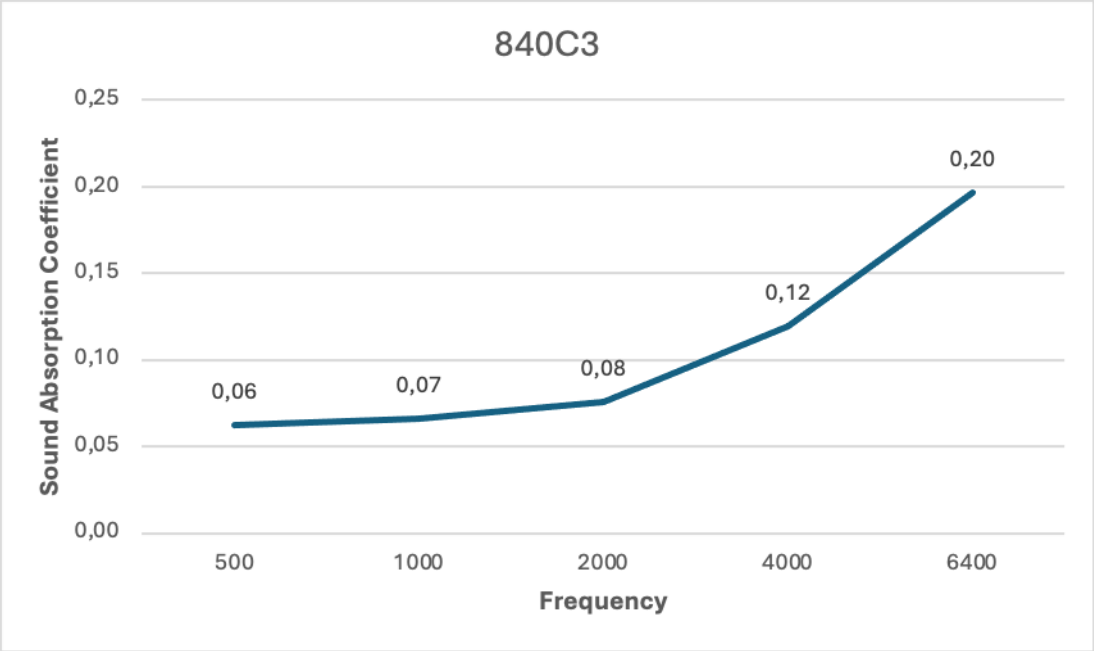

Fig. 4. Sound Absorption Coefficients of the Sample Containing Rice Husk as Additional Material, 3 cm Thick and Cooked at 840°C. (Özbek, 2022).

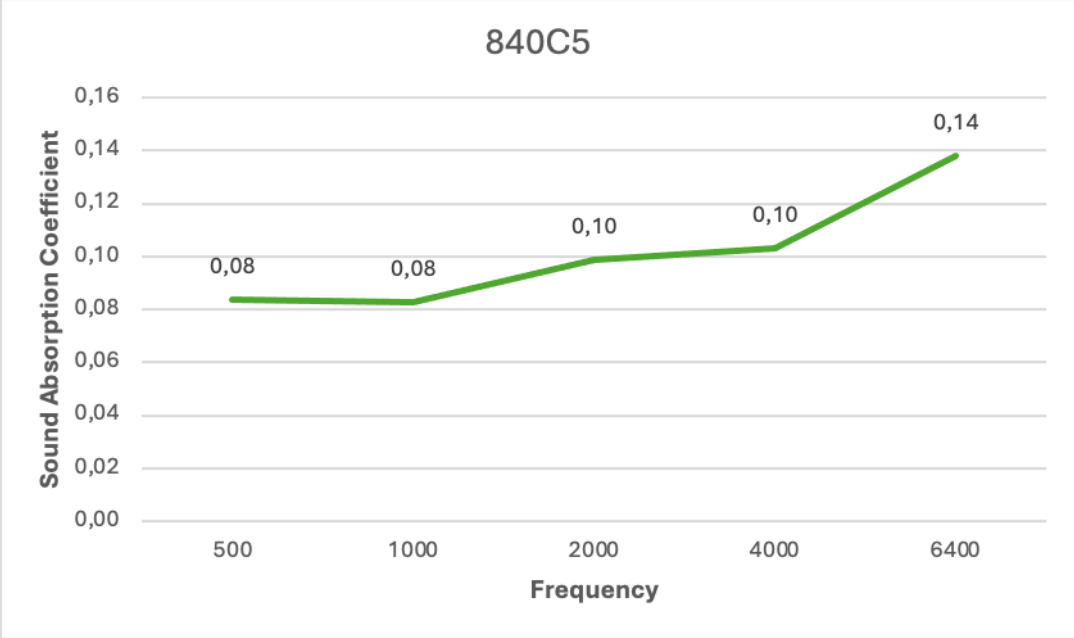

Fig. 2. Sound Absorption Coefficients of the Sample Containing Paddy Husk as Additional Material, 5 cm Thick and Cooked at 840°C. (Özbek, 2022).

Table 1. Sound Absorption Coefficients of the Measured Samples According to Frequencies (Özbek, 2022).

f (Hz)	Sample Name		Sound Absorption Coefficient of Reference Brick Surface4
	840C3	840C5	
500	0.06	0.08	0.03
1000	0.07	0.08	0.03
2000	0.08	0.10	0.04
4000	0.12	0.10	0.05
6400	0.20	0.14	0.05

When the measurement results are reviewed, it is seen that the samples have different sound absorption coefficient values at different frequencies. When we look at all the results, it can be said that the sound absorption coefficients of the samples increase at high frequencies (thin sounds), that is, their absorption increases.

2.4 Effect of Rice Husk Addition on Physical and Mechanical Properties

The addition of rice husks, while primarily aimed at improving the acoustic properties of the material through increased porosity, also has implications for its physical and mechanical properties. Porosity, resulting from the combustion of rice husks during the firing process, can reduce the density and compressive strength of the composite material. This trade-off between acoustic performance and mechanical integrity has been highlighted in previous studies. For instance, Jamil et al. (2013) observed that rice husk ash-based composites tend to exhibit reduced compressive strength due to increased void content, which aligns with the findings of Gupta and Kua (2016).

In this study, while detailed mechanical testing was not the primary focus, preliminary observations indicated a decrease in the material's structural rigidity as the proportion of rice husk increased. This effect is consistent with the behavior of other agricultural waste-enhanced composites, as reported by Torgal et al. (2011). Future research could involve optimizing the ratio of rice husk to clay to achieve a balance between improved sound absorption and acceptable mechanical performance for specific applications.

Furthermore, the thermal conductivity of the material may also be affected by the inclusion of rice husks, as increased porosity generally enhances thermal insulation properties. This characteristic could make the material suitable for dual-purpose applications where both thermal and acoustic insulation are desired (Berardi & Iannace, 2015).

While this study primarily focused on acoustic properties, it acknowledges the need for a comprehensive evaluation of the physical and mechanical performance of the developed material in future work. Such evaluations will ensure its suitability for broader applications in construction and interior design.

3. DISCUSSION

The results of this study demonstrate that the addition of rice husks to brick waste-based composites enhances the sound absorption properties, particularly at higher frequencies. When compared with similar studies, the findings align with existing literature on the acoustic performance of porous materials.

For example, Berardi and Iannace (2015) reported that natural fibers, including agricultural by-products, can achieve sound absorption coefficients in the range of 0.1 to 0.3 at frequencies above 2000 Hz. The material developed in this study achieved comparable coefficients, with values reaching 0.20 at 6400 Hz for the 3 cm thick sample. Similarly,

[4]It is the laboratory result obtained from the manufacturers.

Torgal, Jalali, Faria, and Henriques (2011) emphasized the role of porosity in improving acoustic performance, which is consistent with the observed behavior of the rice husk-infused composites.

In terms of comparison with traditional materials, the developed composite outperforms standard brick surfaces, which typically exhibit sound absorption coefficients below 0.05 across most frequencies (Gupta & Kua, 2016). This improvement highlights the potential of the composite as an effective acoustic solution in construction applications.

Moreover, the study contributes to the broader body of work on sustainable materials. The integration of construction and demolition waste with agricultural by-products aligns with circular economy principles, as highlighted by Silva, De Brito, and Dhir (2014). By transforming waste into value-added products, this study addresses both environmental and technical challenges in material innovation.

However, it is important to note that while the acoustic properties of the material have been extensively evaluated, its mechanical performance and durability under long-term use require further investigation. Future studies should explore these aspects to ensure the material's suitability for practical applications in various construction contexts.

4. CONCLUSION

This study investigated the potential of recycling brick waste and integrating it with rice husks to develop a sustainable acoustic material. The findings demonstrate that the composite material, formed by combining brick waste, clay as a binder, and rice husks, exhibits superior acoustic properties compared to traditional brick surfaces.

Preliminary tests showed that brick waste alone is insufficient for creating cohesive and durable materials due to its brittleness and low bonding properties, as also noted in Silva, De Brito, and Dhir (2014). To address this limitation, clay was introduced to enhance structural integrity, and rice husks were added to increase porosity, leading to improved sound absorption. The material’s porosity, resulting from the combustion of rice husks during firing, played a critical role in enhancing its acoustic performance.

Laboratory evaluations using impedance tube tests confirmed that the composite material achieved significantly higher sound absorption coefficients compared to traditional brick surfaces. For instance, the sound absorption coefficient of the 3 cm thick sample reached 0.20 at 6400 Hz, whereas standard brick surfaces typically exhibit coefficients below 0.05 in similar frequency ranges (Gupta & Kua, 2016). These results validate the effectiveness of the material in providing acoustic insulation, particularly in high-frequency ranges.

In addition to its acoustic performance, the study acknowledged trade-offs in other properties. While the increased porosity improved sound absorption, it potentially reduced compressive strength and density. These findings align with prior studies, such as those by Jamil et al. (2013), emphasizing the importance of balancing acoustic and mechanical properties in porous composites.

This research contributes to sustainable construction practices by offering a method to repurpose low-value construction and demolition waste alongside agricultural by-products. The approach aligns with circular economy principles, transforming waste into high-value materials. However, further studies are needed to optimize the material composition for enhanced structural performance and thermal insulation. Long-term durability testing, additional mechanical evaluations, and comparisons with commercially available acoustic solutions would further strengthen the applicability of this material in real-world construction projects.

By integrating experimental findings with established literature, this study underscores the viability of innovative, waste-based materials as effective solutions for acoustic insulation, addressing both environmental and functional challenges in the construction industry.

ETHICAL STANDARDS:

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Ethics Committee Permission: This article does not require ethics committee approval.

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