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SUSTAINABLE AQUATIC RESEARCH SYMPOSIUM

SUSTAINABLE DEVELOPMENT GOALS

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SUSTAINABLE AQUATIC RESEARCH SYMPOSIUM

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Foreward

Sustainability is a topic that is discussed widely by citizens in many countries. But, what do we understand by **Sustainability**? Definitions centre on the understanding that the planet's natural resources are finite, and need to be managed sensibly addressing concerns for the protection of the natural environment (for example, the impact of pollution, such as by microplastics), societal issues (including job creation/protection) and economic development/vitality (including the need for sustainable tourism). In short, humans need to treat the natural environment with respect and consideration of the needs of future generations. We need to think about our legacy for our children and grandchildren?

The first International "Sustainable Aquatic Research" Symposium took place in Izmir, Türkiye, from May 21-22, 2024. The event featured 59 papers from 21 different countries, including Türkiye (23), Scotland (1), Greece (1), Saudi Arabia (1), Australia (1), Bulgaria (1), USA (1), Philippines (7), Indonesia (4), Italy (1), Pakistan (3), Bangladesh (1), Croatia (1), Iran (5), India (1), Turkmenistan (1), Oman (1), Morocco (2), Romania (1), Algeria (1) and Brazil (1) (Approximately 61 % are from outside Türkiye). The symposium was attended by 123 academicians, researchers, and delegates. The keynote speakers from 6 countries delivered talks on. A range of topics, namely "*Blue Transformation; The Impact of Disease on the Sustainability of Aquaculture; Fisheries in the Mediterranean: Today and in the Future*; *Biosecurity as a Tool for Sustainability; Collaborations in Operation for Sustainable Seafood*; and *Aquatic Animal Nutrition*" that shed light on the current problems of our planet. Thus, the presentations focused on a diversity of topics relevant to the aquatic environment all with the central theme of sustainability. In particular, the Symposium addressed many current issues, and including:

aquaculture

nutrition and the need to replace the current use of protein from trash fish species in commercial diets

disease, and the problems of lost production, and those related to antibiotic use

sustainable brood-stock production enabling controlled production without reliance on using wild caught individuals

aquaponics, which has the benefit of using less water than traditional aquaculture

fisheries

we must not continue to plunder the oceans, wasting any organisms not regarded to be of commercial value

biotechnology

production of commercially useful products from aquatic organisms without overuse of wild caught organisms

The workshop drew attention to issues related to the use of artificial intelligence in ensuring fish welfare. Also, delegates discussed about the role of women, in: "*Woman in Private Sector and Science*". Finally, Professor Addison Lee Lawrence, who contributed to the emergence of the symposium, and whom we lost recently, was remembered. Thus, the Symposium raised awareness of ongoing concerns regarding the aquatic environment, fostered interdisciplinary dialogue and collaboration, inspired actionable strategies that promote the health of our water bodies for future generations, and set the tone for future meetings.

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Opening Speech

Distinguished Participants,

I am delighted to welcome you all here today as we take a significant step forward in the field of sustainable aquatic research. I extend my gratitude to everyone who has contributed to the organization of this symposium.

FIRST OF all,

I would like to thank to,

Our esteemed Rector Professor Saffet Köse, who encouraged us and supported us in the planning and organization of this symposium.

TO Dear Prof. Dr. Brian Austin, for his miraculous efforts in the formation and germination of the idea of the symposium until now,

TO the international organizing committee, with whom we made all decisions together,

and of course, all the researchers and scientific committee members who participated to present their studies on the subject,

and also great thanks to the symposium secretariat for their kind efforts

Lastly, many thanks to the keynote speakers who accept our request,

and all of you dear participiants…

We all know that “Water” is the essence of life. It is indispensable for both humanity and all living beings. However, the sustainability of water resources is becoming increasingly crucial. Factors such as population growth, industrialization, and climate change threaten our water resources. Scientific research and applications are essential to cope with these threats and to leave a livable world for future generations.

Today, we have gathered here as experts and researchers from around the world to share the latest findings and innovations in sustainable water management and conservation, to exchange our experiences, and to develop strategies for the future.

In this symposium, we will address topics such as the conservation of aquatic ecosystems, improvement of water quality, management of water resources, prevention of water crises, and the economic, social, and environmental dimensions of water. We must not forget that our work in these areas is of great importance not only scientifically but also for the well-being of our society and the sustainability of our planet.

Today, we are not only launching a symposium. We are also making a commitment to the future of water. We pledge to protect water resources, to manage them better through scientific research and collaboration, and to build a fairer and more sustainable future.

I hope this symposium will be a platform where new ideas, inspiring discussions, and effective solutions emerge. I wish you all a productive and enjoyable symposium period, and I thank you in advance for your contributions.

Thank you very much…

Prof. Dr. Erkan CAN

Rector's Message

Dear researchers, participiants,
We are very happy to see researchers from all over the world participating here to exchange knowledge and ideas on sustainable aquatic research.
Water is essential for the sustainability of life on our planet. Protecting and responsibly managing water resources is a critical component of a prosperous future for all living organisms on Earth.
Therefore, the duty of humanity is to protect and manage water in the best way possible, within the framework of international cooperation and common sense.
We believe that your vast experience and expertise in the field of sustainable use of water will make a valuable contribution to the symposium. Your participation in this event will enrich the discussions and help us move closer to finding innovative solutions to the challenges facing aquatic ecosystems.
We have full faith that your contribution to this symposium will create a synergistic effect and raise awareness about the sustainable use of water.
I would like to thank everyone who contributed to this organization.
Best regards,

Professor Dr. Saffet KÖSE
Rector of Izmir Katip Çelebi University

Sevgili araştırmacılar, katılımcılar
Sürdürülebilir su araştırmaları konusunda bilgi ve fikir alışverişinde bulunmak için dünyanın dört bir yanından katılan araştırmacıları burada görmekten çok mutluyuz.
Su, gezegenimizdeki hayatın sürdürülebilirliği için elzemdir. Su kaynaklarının korunması ve sorumlu bir şekilde yönetilmesi, Dünya üzerindeki tüm canlı organizmalar için müreffeh bir geleceğin kritik bileşenidir.
Bu nedenle insanlığın görevi, uluslararası işbirliği ile sağduyu çerçevesinde suyu en iyi şekilde korumak ve yönetmektir.
Suyun sürdürülebilir kullanımı alanındaki engin deneyim ve uzmanlığınızın sempozyuma değerli bir katkı sağlayacağına inanıyoruz. Bu etkinliğe katılımınız tartışmaları zenginleştirecek ve su ekosistemlerinin karşı karşıya olduğu zorluklara yenilikçi çözümler bulmaya daha da yaklaşmamıza yardımcı olacaktır.
Bu sempozyuma katkınızın sinerjistik bir etki oluşturacağına ve suyun sürdürülebilir kullanımı konusunda farkındalığı artıracağına inancımız tamdır.
Bu organizasyonda emeği olan herkese teşekkür ederim.
Selamlarımla,

Profesör Dr. Saffet KÖSE
İzmir Katip Çelebi Üniversitesi Rektörü

Blue Transformation

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Blue Transformation is a vision for FAO regarding transformation of aquatic food systems. It envisions the transformation of aquatic food systems to enhance their contribution to global food security, nutrition, and affordable healthy diets, in line with the Sustainable Development Goals. It calls for more efficient, inclusive, resilient, and sustainable practices that are climate, water, and environment-friendly. The speech discusses the challenges posed by climate change, environmental degradation, pollution, and biodiversity loss, and emphasizes the need for robust management measures to support fishing communities and sustainable aquaculture development. The importance of public and private partnerships in driving technological innovation and policy-making for long-term sustainability is highlighted. Blue Transformation builds on existing successes while providing a framework to overcome sustainability challenges. This transformation is seen as essential to achieving long-term ecological health while supporting economic activities like fishing, tourism, and renewable energy. Promising practices and techniques are already in place.

Keywords: Blue economy, marine biodiversity, mquatic ecosystems, mustainable development, FAO

The impact of disease on the sustainability of aquaculture

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Disease is a way of life for all multicellular species on the planet – from plants to fish to terrestrial mammals. In terms of aquaculture, there is inevitably a large number of individuals, usually of the same species, within confined spaces in an aqueous medium that enables the rapid proliferation and spread of pathogens. Thus, the aquaculture environment is ideal for the transmission and spread of disease, which results in global losses of ~US$6 billion, annually. It is not uncommon that separately owned and/or managed aquaculture facilities are located close to each other. Therefore, the effluent from one site would be the inflow to the next. This facilitates the rapid dissemination of pathogens. Moreover, farmed species are often in close proximity with wild animals, and thus there may be an exchange of microflora, including potential pathogens. This situation is exacerbated when species, which are exotic to an area, are introduced to aquaculture and acquire pathogens from native animals. Unfortunately, the introduced species may have little or no resistance leading to higher levels of clinical disease and mortalities than recorded in native animals. Certainly, sites are dependent on the vagaries of the surrounding aquatic environment, namely water flow, aeration, pollutants and indigenous organisms/pathogens, which may impact on the health of the farmed species. In short, there may be issues with poor hygiene, overcrowding, inadequate water flow, pollution, hypoxia and suboptimal temperatures, any of which may impact adversely on health. Notwithstanding the economic problems of mortalities, visibly diseased animals with deformities or lesions may be unsaleable. Moreover, the presence of some diseases may result in poor feed conversion leading to reduced/stunted growth, which will adversely affect production costs. In addition to these concerns, there is the concern about climate change/global warming and its impact on disease. Arguably, higher temperatures would stress many animals making them more susceptible to disease. Unlike their wild counterparts, farmed animals would be unable to move to more acceptable water temperatures. Then, there is the unknown factor about the impact of higher temperatures on pathogen virulence. However, the awareness of problems leads to solutions, and mitigation involves: - better site selection to avoid polluted areas, the proximity to other farms, and/or areas of poor water supply. - a sensible choice of the species/strain to be farmed, if possible involving stock resistant to diseases known to occur in the general area - the use of sensible disease control strategies, emphasising preventative [= prophylaxis] rather than curative measures [= therapy] encompassing vaccines, nonspecific immunostimulants, probiotics and/or medicinal plant products. In terms of sustainability, the aquaculture industry must adopt realistic stocking levels in well managed sites with good water supplies and nutritious feed to obtain more healthy animals with good sales potential.

Keywords: Fish health, sustainability, aquaculture, disease control strategies, aquatic Organisms

Fisheries in Mediterranean: Today and Future

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Fisheries in the Mediterranean (and also in Black Sea) generate an annual revenue of $2.9 billion and an estimated half a million jobs throughout the value chain. An average 1 in every 1 000 coastal residents in the region is a fisher, and in some coastal areas that number can be up to 10 times higher. However, the workforce is ageing as in 2020 more than half of all crew were over the age of 40, while only 10 % were under 25 years old. Small-scale fisheries accounts for 82% of the vessels and 59% of the jobs, employing the highest number of young people, but fishers earn typically less than half the wage earned by fishers on industrial fleets. In this frame, GFCM 2030 offers a common vision and guiding principles to achieve sustainable fisheries, federating efforts to deliver on national, regional and global commitments. This strategy also upholds the heritage of fisheries as pillar for the livelihoods of coastal communities, championing a productive and sustainable food system that contributes to thriving economies and healthy ecosystems.

In the Mediterranean and Black Seas, there are indications that fishing pressure has decreased since 2019, although no substantial increase in biomass has been observed since 2011. Recent advances in increasing the number of stocks and ongoing work in ICES, GFCM and STECF EWGs has been conducted to increase the number of stocks with key reference points further. However, in the Mediterranean and Black Seas, stock status and trends are only assessed for a limited number of stocks. Despite the last 2 years' increase in the number of stocks available, there is still a need to increase the coverage of stocks in the CFP monitoring analysis to increase the representativeness of the indicator values for the above-mentioned areas.

In Greek waters, the term "overfishing" had already been spreading since the beginning of the 20^{th} century through discussions concerning the overexploitation of fishing stocks, especially in the semi-enclosed bays near the urban centers, where, at that time, most of the Greek fishing was concentrated. Also, during 1949-1955, the percentage of first economic category of fish species (where they made up 8-10% of the landings production) has been considerably decreased, while on the contrary the participation of low-valued species has been increased. Nevertheless, at that time the average official fishery production of the 1960s was almost 50% less than that of 2010.

Pollution of the seas and the degradation of the coastal environment constitute an important burden on fishing stocks and not only them. There are numerous reports of anthropogenic interventions and activities such as agricultural development, intensive residential development, large infrastructure projects, interventions in rivers and streams, tourism and industrial activity, which degrade the coastal zone, a critical ecosystem for young stages of many fish species. These problems are not a "privilege" of the modern era, but they have also been observed for 50 years. According to historical information 40 years ago "the degradation of the value of the coasts if it does not excite those responsible for environmental reasons, it should excite them from the point of view of adverse economic effects".

The alteration of marine habitats by anthropogenic interventions reduces the probability of survival, recruitment and subsequently the abundance of the stock and consequently the fishing yield of mainly small coastal fisheries. Due to these interventions, food webs of the aquatic ecosystems is becoming unbalanced with indiscriminate consequences, some of which are clearly visible. Last but not least, it is important to note that there is no fishing without data, because the "footprint" of fishing, as a social activity, is included in many sectors of the economy, such as employment, consumption, fuel requirements, etc.. This advantage of the fisheries sector might be a useful tool for reducing the uncertainty produced by the major challenges that fisheries sector face such as illegal, unreported and unregulated (IUU) fishing, climate change, plastic pollution, economic hardships and now Covid-19.

Aquatic Animal Nutrition

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Demand for seafood continues to increase at a rate which will require a significant global increase in farmed-fish production over the next 25 years. To meet that demand, feedstuffs that can be used in economically viable and sustainable aquafeeds must be further developed and evaluated although great progress has been made in this regard over the last decade. Various complementary protein feedstuffs of various origins have been identified and are now regularly included in aquafeeds to lessen dependence on fishmeal. As such, feedstuffs of marine origin have now become strategic ingredients, typically used at lower inclusion levels, to extend their availability and use in aquafeeds to support increased aquaculture production. The nutritional characteristics of various groups of protein feedstuffs including those of marine origin, plant protein concentrates, processed animal proteins, and single cell proteins are presented in detail. Traditional as well as novel protein feedstuffs will continue to be developed and used in aquafeeds to support expanded production of seafood from aquaculture to meet the demands of a growing world population.

Keywords
Aquaculture, nutritional requirements, feeding strategies, feed efficiency, sustainable practices

Biosecurity as a tool for sustainability: from management reaction to strategic planning

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Aquaculture is an economic activity sustainability biosecurity measures need to be defined to contribute to the profitability of the industry in the long term. Effective biosecurity requires a multilayer approach: international, national and farm levels, each of them have different objectives and actors. Farm level biosecurity has a very broad spectrum of action covering different aspects related to the animal, to the pathogen and the environment. Biosecurity plans are specific to the facility, the species, the endemic and emerging pathogens, culture system etc… Considering the broad spectrum of biosecurity, the presentation will focus only on the importance of epigenetics, both on the positive and negative side and how it can be used to improve farm performance. Diseases have proven to be one of the major threats to the sustainability of the aquaculture industry. They have caused severe economic impact at all levels, starting with small farmers, corporate companies up to national economies. Diseases have a wide range of expression. They may range from severe and acute mortality to low chronic mortality or slow growth. There are various definitions of biosecurity that could be synthesized as all the actions needed to prevent and manage diseases reducing their economic impact. Biosecurity uses different tools to implement its strategies working at three different levels: international, national and farm level. International standards and agreements are needed to prevent the transboundary movement of pathogens and protection of regional health status. These relates to the control of importation of life aquatic animals, fresh and frozen aquaculture products for reprocessing and the handling of ballast water. The risks, possible strategies and monumental difficulties to implement them are discussed in this presentation. Suitable national legislation is required, again to prevent the transboundary movement of pathogens, early detection of pathogens through surveillance programs, reference diagnostic laboratories, suitable use of veterinary drugs and geographic zonation and compartmentalization Eventually, farm level biosecurity needs to consider different strategies depending on the culture system used and endemic pathogens. The suitable genetic characteristics of the broodstock and their health status are crucial for the success of the culture. Exclusion versus pathogen management approaches will depend on the economic impact of diseases, the stage of culture and the type of pathogen. It is important to try to balance the economic risk of the disease and the investment in biosecurity. In addition to the diseases caused by primary pathogens, there are also the ones caused by opportunistic pathogens. In these cases, the veterinarian/aquatic animal health specialist needs to be integrated into the production process to properly interpret the situation and identify the root of the problem.

KEYWORDS: Aquaculture, sustainability, diseases, shrimp, biosecurity, health, profitability. Victoria Alday-Sanz is a veterinarian with an M.Sc. and Ph.D. from Stirling University (UK). She has worked for over 30 years on diverse aspects of shrimp and fish health issues covering research on pathogens and diseases, diagnostics, sanitary legislation, health management, development of SPF stocks and biosecurity. She has collaborated as an expert for international organizations such as FAO, WOAH, EU, EFSA and WB as well as with the private sector. She has lived and work in Southeast Asia, Middle East and Latin America and published over 35 papers in peer review journals, over 50 articles in industry magazines, 5 book chapters, is co-author of the CD-rom Diagnosis of Shrimp Diseases and editor of The Shrimp Book I and II. She was director for Aquaculture Biosecurity for Pescanova where she led the development of a population of "reverse SPF" shrimp (Specific Pathogen Free and Specific Pathogen Tolerant stocks). Presently, she is the Director for Biosecurity, Breeding programs and Research and Development for the National Aquaculture Group of Saudi Arabia.

Collaboration in Operation for Sustainable Seafood

Hon Prof Roy D Palmer

Founder Association International Seafood Professionals

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Events and a Training platform where we teach some basics are important areas are those immediate areas under consideration on "Collaboration in Operation for Sustainable Seafood". I raise training as I feel that is an Achilles heel for the seafood industry as a whole.

I hope that it develops and increases into the future. Events can maximise our exposure. I will communicate on issues from our latest event – Aqua Farm 2024 held on Gold Coast 13-15 May 2024 – the theme was "Increasing Seafood Consumption through Aquaculture Development using an ESGH Framework".

Some wonderful things were achieved at this event. Networking was exceptional, there were people from China, USA, Canada, Mexico, Spain, UK, Norway, Germany, New Zealand, France, Thailand, India, The Netherlands, Ecuador, Oman, Iran, Italy, Vietnam, South Korea and importantly there were people from Torres Strait Islanders who wanted to meet and learn from the experts present. A quality program and quality people and those present enjoyed the open and friendly approach to the event – sharing of knowledge and information was immense so that was a success.

Aqua Farm 2024 invested in a JV with AgVisor Pro which is a Canadian app for your phone which has enabled us to start a community which will continue way beyond the event. Its free and you are welcome to join (download through Google or Apple) and it will be a great way to communicate for other events that we do together as well as communicate with other people from all over the world. These can be private or public conversations so the App is a success but like everything in life will only be a valuable resource if we all engage.

There were failures and we learned that COVID was still alive and well – we lost 3 of our speakers to COVID and a number of delegates. One of the failures of our event was getting Government buy in. Erik Hempell gave the audience his views about the differences in aquaculture in Norway, EU and Australia and he was spot on. Australia has a lack of political will on aquaculture and is clearly missing major opportunities as a result.

I am planning a new venture with the commencement of Seafood Consumers Association (www.seafoodconsumers.global).

Thank you for the opportunity to share details about AF24 and I/we look forward to engaging more in the future. I wish you all a healthy life and safe travel – and do not forget '**Sea Food and Eat it'**

This presentation is made available to anyone who would like a copy. You can contact Professor Erkan Can or myself (email seafoodsdg@outlook.com).

Workshop on the Welfare Footprint Framework: Enhancing Aquatic Animal Health and Welfare

Wladimir J. Alonso & Cynthia Schuck-Paim

Center for Welfare Metrics, Brazil

The inclusion of animal welfare in discussions on sustainability is becoming increasingly important as consumers demand higher ethical standards for the products they purchase. Sustainability extends beyond environmental and economic considerations; it also encompasses the humane treatment of animals in production systems. Products perceived as coming from inhumane conditions are unlikely to be deemed sustainable by consumers. This workshop focuses on the Welfare Footprint Framework, an innovative method designed to quantify animal suffering under various challenges and living conditions using a biologically meaningful metric: time in affective states of different intensities. This metric provides a comprehensive assessment of welfare, enabling stakeholders to identify and implement the most effective strategies to enhance animal well-being. For this conference, we exemplify the application of the Welfare Footprint Framework by describing and quantifying the suffering associated with asphyxiation from air exposure in fish. This specific case study highlights the method's capability to address and measure acute welfare challenges in aquatic species. Additionally, the workshop demonstrates how Artificial Intelligence (AI) is employed to accelerate our analyses through the use of a Custom GPT called 'Pain-Track' (https://chatgpt.com/g/g-uzm30LW4j-pain-track). This AI tool significantly speeds up welfare assessments by providing an initial draft of a scientific paper with Pain-Track and Cumulative-Pain analyses. Researchers can then use this advanced starting point to correct, expand, and complete their studies. Attendees will learn how to access and utilize Pain-Track for their research and practical applications. By integrating animal welfare into the sustainability dialogue, this workshop underscores the critical role of ethical considerations in ensuring truly sustainable practices in animal production. The 1st International Symposium on Sustainable Aquatic Research is to be commended for its foresight in promoting this integration.

Keywords: Aquatic animal welfare, sustainability, welfare footprint, metrics, artificial intelligence

Topic Sessions

Alternate Aquatic Energy Technologies
Aquatic Animal Nutrition
Aquatic Sustainability
Aquaculture and Fisheries
Aquatic Environmental Interactions
Aquatic biochemistry
Aquaculture and environment
Aquaculture and risk assessment
Aquatic ecotoxicology
Aquatic living resources
Aquatic Biofuels
Aquatic Biotechnology
Climate Change and global warming
Coastal Zone Management
Ecofriendly aquaculture studies
Environmental impacts of aquaculture
Fish Health and Welfare
HalogenomicsHuman and Environmental Risk Assessment
Hydrology and Water Resources
Impacts of global environmental changes
Innovative livestock and farming systems
Marine and Freshwater Biology
Marine and Freshwater Pollution
Seafood Quality and Safety (Monitoring safety aspects)
Sustainable seafood consumption for consumers
Sustainable and Renewable Resources
Sustainable Aquatic Ecosystem
Sustainability assessment and design of aquacultural systems and decision support tools
Technological processes to improve food quality
Water Quality and Pollution
Wastewater Treatment
And more research focused on sustainability like advanced approches to assesing animal welfare and succesfull broodstocks

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SUSTAINABLE AQUATIC RESEARCH SYMPOSIUM

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CONGRESS PROGRAM

DAY 1 - May 21, 2024

(Oral - 12 min + 3 min, Keynotes 25 +5 min, Plenary 30 +5 min)

Türkiye Time

8.00-9.00	***Registration*** ***https://us06web.zoom.us/j/89837933356?pwd=zsB40tKzQUgkvsfkPsotbP4ZKGCh77.1*** ***(for the General Sessions and the Sessions 1, 2, 3 and 4)*** ***Meeting ID: 898 3793 3356*** ***Password: 855073*** ***https://us06web.zoom.us/j/89143299150?pwd=F2nUBPhs0PbZwF3Na9o8xgFmwNTBl6.1*** ***(for the Sessions 5, 6, 7 and 8)*** ***Meeting ID: 837 4630 7265*** ***Password: 526523***
9.00-9.15	***Opening Ceremony***
9.15 -9.50	***Plenary Session*** Opening speech, Prof. Dr. Erkan Can Rector's message, Prof. Dr. Saffet Köse Blue Transformation, Dr. Haydar Fersoy from FAO
09.50-10.00	***Group Photo***
10.00-10.30	***Keynote, Prof. Brian Austin,*** **" The Impact of Disease on the Sustainability of Aquaculture"**
10.30-11.00	***Keynote, Assoc. Prof. Dimitrios K. Moutopoulos*** **"Fisheries in Mediterranean: Today and Future"**

	Session 1 (Room 1) Chair Prof. Dr. Kim Thompson Co-Chair Assoc. Prof. Dr. Ebru Yılmaz	Session 5 (Room 2) Chair Prof. Dr. Naim Sağlam Co-Chair Asst. Prof. Dr. Keriman Yürüten Özdemir
11.00-11.15	*Clinically Important Vibrio Diversity in the Black Sea* Petya Orozova, Rumiana Nenova, Iskra Tomova, Lilia Gorjanova, Gergana Krumova-Vulcheva, Dimitar Ivanov, Ognyana Hristova, Plamen Mitov	*Lead-210 concentration in Sea Urchins (Paracentrotus lividus) and Patella (Patella vulgata) Species in Izmir-Urla Bay, Türkiye* Duygu Arslantürk, Aysun Uğur Görgün, Işık Filizok
11.15-11.30	*Unveiling Ice-ice Disease in Eucheumatoid Seaweeds: Insights from Farmers' Experiences* Albaris B. Tahiluddin	*Evaluation of the Effects of Experimental Parameters on COD Removal from Leachate Water by Electrocoagulation Process* Aysenur Ogedey, Ensar Oguz
11.30-11.45	*Multistrain Probiotics Enhance the Growth Performance, Survival and Improve the Health Status of Labeo rohita* Iffat Amin, Saima Naveed, Shahzad Naveed Jadoon, Tooba Khan, Jamila Fatima, Momna Khalid	*Effects of Microplastics on Aquatic Organisms* Muhammed Selçuk Çelik, Sevim Hamzaçebi
11.45-12.00	*Emerging Contaminants Oxidation with Ozone* Cristian Carboni	*A Study on Morphometric and Meristic Biology of Asian Stinging Catfish Heteropneustes fossilis (Bloch, 1794): A Key for Identification* Akhand Pratap Singh, Vandana Kumari, K. M. Ranjana, C. Vijayakumar
12.15-12.30	*Assessment of the Production Performance of Rohu (Labeo rohita) in Cage Culture with Tilapia (Oreochromis niloticus)* Mohammad Lokman Ali, Tridip Ray	*Bioaccumulation and Impacts of Microplastics in Aquatic Plants* Gülşen Müge Kahraman, Filiz Kutluyer Kocabaş, Mehmet Kocabaş
12.30-12.45	*The Effects of Microplastic Exposure on the Growth Characteristics of the Green Algae Chlorella sp. Used in the Aquaculture Industry* Cemre Ağaoğlu, Tuğçe Sezgin, Altan Özkan	*Risk Assessment of Microplastic Contamination in Qarasoo Basin, Southern Caspian Sea* Tahere Bagheri
11.45-13.00	*Aquaculture and Environment: Perceptions of Pollution and Sustainability within the Local Community's Context in the Croatian Adriatic Sea* Mislav Škacan	*Diel Variation in Bottom-trawl Species Diversity in Izmir Bay (the Central-Eastern Aegean Sea)* Şebnem Sinem Uluözen, Aydın Ünlüoğlu

13.00-14.30 **Break "lunch"**

	Session 2 (Room 1) Chair Güzel Yücel Gier Co-Chair Dr. Övgü Gencer	Session 6 (Room 2) Chair Prof. Dr. İlker Zeki Kurtoğlu Co-Chair Assoc. Prof. Dr. Filiz Kutluyer
14.30-14.45	*Improvement Effects of Vitamin C on Hematological Indices and DNA Breakage in Common Carp (Cyprinus carpio) after Exposure to Zinc-Oxide Nanoparticles* Aliakbar Hedayati, Tahereh Bagheri, Hadise Kashiri	*Monitoring the studies on feed selection for raising young trout in a commercial trout farm* Allamyrat Geldiyev, Ramazan Serezli
14.45-15.00	*Development of Protocol for Cryopreservation of Climbing Perch (Anabas testudineus) Sperm* Zainal Abidin Muchlisin, Siti Maulida, Luvi Safrida Handayani, Kartini Eriani, Nur Fadli, Nanda Muhammad Razi, Nelly Feryanti, Mehmet Kocabas, Filiz Kutluyer Kocabas	*Ecosystem Characteristics and Trophic Model of the Artificial Reef Ecosystem in the Sea of Oman, Sultanate of Oman* Sabrina Al Ismaili, Sachinandan Dutta
15.00-15.15	*Culture of Sea Lettuce (Ulva rigida) in Wastewater of Aquaculture Facilities* Muhammet Kürşat Bağcı, Gamze Turan	*Present Status of Fish Harvesting, Fisheries Resources and Fish Consumption in Pakistan* Farzana Abbas, Muhammad Hafeez-ur-Rehman
15.15-15.30	*Replacement of Fish Meal with Soybean Meal in the Practical Diets for Giant Murrel, Channa marulius (Hamilton1822): Growth, Feed Utilization, and Digestibility* Muhammad Hafeez-ur-Rehman, Farzana Abbas	*Reproductive Parameters of Pike Perch Sander lucioperca (Linnaeus, 1758) in the Al Massira Dam Lake (Morocco)* Meriem Bousseba, Loubna Ferraj, Sara Ouahb, Mohammed Droussi, Mustapha Hasnaoui
15.30-15.45	*Ulva sp. as Potential Bio-adsorbent for Bromophenol Blue Dye (BPB)* Merilyn Q. Amlani	*Length-based Assessment Method for the Improved Management of Sander lucioperca (Linnaeus, 1758) Fisheries in the Continental Waters of Morocco* Meriem Bousseba, Sara Ouahb, Loubna Ferraj,Mohammed Droussi, Mustapha Hasnaoui
15.45-16.00	*The Anesthetic Effects of Lemon Peel Oil on Rainbow Trout (Oncorhynchus mykiss Walbaum, 1792)* Ferhat Bakır, Baki Aydın	*Impact of Tidal Mixing on Mixed Layer Depth Variability in the Northern Bay of Bengal* M.N. Hidayat, R. Wafdan, M. Ramli, Z.A. Muchlisin, S. Rizal
16.00-16.15	*An Indigenous Small-scale Recirculating Aquaculture System for High-density Fish Culture: Sustainability in Action* Ambadi Kannan Maliyekkal Sajeevan, I. S. Bright Singh, Jayesh Puthumana, Soumya Balakrishnan	*Radiological Assessment on Consumption of Fish from Kinik Stream Near Contaminated Fly Ash Dump Site of Seyitömer Thermal Power* Yusof-den Jamasali, Şeref Turhan
16.15-16.30	*Spatial Analysis of Güllük Wetland Earthen Ponds with Digital Technology* Güzel Yücel Gier, Ceren Coşkunışık Bozdağ, Atilla Hüsnü Eronat	*By-catch/ Discard of Turkish Marine Fisheries and their Impact on Sustainability* Remzi İlik, Hakkı Dereli

16.30-16.45 **Break**

	Session 3 (Room 1) *Chair* *Dr. Cristian Carboni* *Co-Chair,* *Dr. Övgü Gencer*	*Session 7 (Room 2)* *Chair* *Prof. Dr. Mehmet Kocabaş* *Co-Chair,* *Esin Bagcı*
16.45-17.00	***Seaweed Aquaculture for Food Security and Environmental Health*** Gamze Turan	***Edible Marine Gastropod and Bivalve Species: Fresh and Culinary Offerings in the Local Market During Ramadan in the Southernmost Province of the Philippines*** Gerly-Ayn Tupas, Gerwin Tupas, Soner Bilen
17.00-17.15	***Black Soldier Fly Larvae Oil: Application for Sustainable Aquafeed*** Rudy Agung Nugroho, Retno Aryani, Esti Handayani Hardi, Hetty Manurung, Rudianto, Nawwar Mardiyanto	***Carbon Footprint in Fisheries and its Importance for Sustainability*** *Hüseyin Akbaş, Hakkı Dereli*
17.15-17.30	***Current Status in Carp Sperm Cryopreservation*** Mehmet Kocabaş, Luvi S. Handayani, Filliz K. Kocabaş, Zainal A. Muchlisin	***Effects of Different Concentrations of Inorganic Fertilizer on the Growth, Carrageenan Yield and Gel Strength of*** ***Kappaphycus alvarezii*** Rizal Jhunn F. Robles, Hadjira A. Illud, Concepcion C. Toring, Cherry T. Nian, Rosalinda P. Shariff
17.30-17.45	***Effects of Different Ratios of Groundnut Meal Supplemented Diets on Digestive and Antioxidant Enzymes and Growth Parameters of Rainbow Trout (Oncorhynchus mykiss, Walbaum, 1792)*** Seval Dernekbaşı, Dilara Kaya Öztürk, Keriman Yürüten Özdemir, İsmihan Karayücel	***Impact of Multiple Stressors on the Resilience of Mediterranean Zooplankton Communities*** Kıes Fatima, Boucetta Sabrine, Cheikh Djeouti Djamila
17.45-18.00	***Study on Effect of Garlic Extract on Bacterial Disease in Shrimp Farming*** Patel Tirthraj	***Carrageenan Yield and Quality of Raw Dried Seaweeds from Tawi-Tawi, SW Philippines*** Abdel-Azeem M. Alsim, Claudine Ann M. Nakila, Sarah-Mae A. Sulbani,Sitti Zayda B. Halun
18.00-18.15	***Interactions between Maritime Shipping and Offshore Aquaculture*** Demet Ağaoğlu	**Exploration of Nitzschia from the Coastal Waters of Suak Ribee, West Aceh Regency, Indonesia** Elya Putri Pane, Yenny Risjani, Cüneyt Nadir Solak, Yunianta, Mehmet Kocabaş, Luvi S Handayani

DAY 2 - May 22, 2024

(Oral - 12 min + 3 min, Keynotes 25 +5 min, Plenary 30 +5 min)

13.00-13.30	***Keynote, Dr. Victoria Alday-Sanz*** **"Biosecurity as a Tool for Sustainability"**
13.30-13.45	**"Woman in Private Sector and Science"** Discussion*

	Session 4 (Room 1)	Session 8 (Room 2)
	Session 4 (Room 1) ***Chair*** ***Prof. Dr. Aliakbar Hedeyati*** ***Co-Chair*** ***Assoc. Prof. Dr. Ebru Yılmaz***	***Session 8 (Room 2)*** ***Chair*** ***Prof. Dr Z. A. Muchlisin*** ***Co-Chair*** ***Asst. Prof. Albaris B. Tahiluddin***
13.45-14.00	***Improving the Antioxidant Defense System of Common Carp (Cyprinus carpio) Exposed to Zinc-Oxide Nanoparticle with Probiotic Lactobacillus*** Aliakbar Hedayati, Tahereh Bagheri, Hadise Kashiri	***In Vitro Toxicity of Triclosan in the Oyster, Crassostrea madrasensis*** Soumya Balakrishnan, Ambadi Kannan Maliyekkal Sajeevan, Sreevidya Chandrasekharan Parvathi, I. S. Bright Singh, Jayesh Puthumana
14.00-14.15	***Effect of Vermicompost Supplement on Rainbow Trout Performance*** Ali Parsa, Erkan Can	***Bridging the Gap between Fishponds Management and Avian Conservation: the Case of Dumbrăvița Fishing Complex – the Most Important Stopover for Black Storks in Romania*** Ciobotă Mihaela, Ciobotă Andreea, Murariu Dumitru
14.15-14.30	***As a Sustainable Aquaculture Technique: Aquaponics and Future Focus*** Erkan Can, Kıymet Deniz Varlı	***Length-weight Relationship of Spotted Sardinella (Amblygaster sirm) from Fish Market of Población, Bongao, Tawi-Tawi, Philippines*** Ariel J. Ricablangca, Khadiza H. Imlan, Fatima Shaina S. Sahipa, Aminashedralyn I. Sansawi
14.30-14.45	***Antibiotic Resistance Risk is Growing Issue for Aquaculture*** Ebru Yılmaz, Sevdan Yılmaz, Hamidreza Ahmadniaye Motlagh, Sebahattin Ergün	***Development Protocol for Cryopreservation of Climbing Perch Anabas testudineus Sperm*** ZainalAbidin Muchlisin[1]*, Siti Maulida[2], Luvi Safrida,Handayani[2], Kartini Eriani,[3] Nur Fadli[1], Nanda Muhammad Razi[2], Nelly Feryanti[1], Mehmet Kocabas[4], Filiz Kutluyer Kocabas[5]

14.45-15.00	***Potential Nutritional Benefits of US-Caught Crab Species Through Panel Data Analysis Forecasting 1950–2021*** Övgü Gencer	***A Preliminary Assessment of Coastal Fisheries in Illana Bay, Philippines*** Jonald Bornales, Ramjie Odin, Greta Noquilla
15.15-15.30	***Investigation of the Utilization Potential of Haematococcus sp. (Flotow, 1844) in Carbon Quantum Dot Production*** Mesude İsar, Side Selin Su Yirmibeşoğlu, Taylan Kurtuluş Öztürk, Gamze Turan	***Immobilization of Inorganic Sulfide on Dead Coral (Acropora cervicornis) Coated with Chitosan as an Adsorbent for Dissolved Mercury(II) Ions*** Muhammad Adlim, Devita Elfa, Ibnu Khaldun, Muhammad Hasan, Musa Yavuz
15.30-15.45	***Study on Bioaccumulation and some Physiological Effects of Nanoplastic on Goldfish (Carassius auratus)*** Aliakbar Hedayati, Safoura Abarghouei, Tahere Bagheri, Mohammad Gholizadeh, Mohammad Zakeri	***Determination of Minimum Inhibition Concentration of Aeromonas hydrophyla Bacteria by Using Moringa oleifera Ethanolic Extract*** Keriman Yürüten Özdemir , Enraida Imbuk, Rahmi Can Özdemir
15.45-16.00	***Importance and Control of Morganella morganii in Seafood*** Dilek Kartal, Fatma Öztürk, Hatice Gündüz	***Elektrokoagülasyon Prosesi ile Sızıntı Suyundan KOİ Gideriminde Deneysel Parametrelerin Etkilerinin Değerlendirilmesi*** Aysenur Ogedey, Ensar Oguz

16.00-17.00	**Workshop on Cumulative Pain Framework,** **" Leveraging Artificial Intelligence for Assessing Fish Health and Welfare", Wladimir J. Alonso**
17.00-17.30	***Keynote,*** *Hon. Prof. Roy. D. Palmer* ***"Sustainable Seafood" (Australia)***

17.30-19.00	***" Remembering Professor Addison Lee Lawrence"*** *Prof. Mark Lawrence* ***"in Memory of Addison" (USA)*** ***Keynote,*** *Prof. Delbert Gatlin III* ***"Aquatic Animal Nutrition" (USA)***
19.00-19. 30	***Round Table-Discussion –Future Perspectives***

End of the event

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Clinically important *Vibrio* diversity in the Black sea

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Abstract

The genus *Vibrio* include ubiquitous group of marine bacteria belonging to the *Gammaproteobacteria* class, the most diverse class of Gram-negative bacteria. As heterotrophic organisms, *Vibrio* spp. live freely in marine aquatic environments, from the bottom to the surface of the water column. Some *Vibrio* spp. are human and animal pathogens, and there are evidences that infections caused by vibrios are increasing worldwide. Little is known about *Vibrio* spp. diversity and abundance in Bulgarian aquatory. The main objective of this study is to gather information regarding the ecology of *Vibrio* species and their potential health risk for human and animals both. During the summer of 2021 - 2023 sea water samples from different sites and depth of Bulgarian Black Sea area were collected. The water samples were investigated for base physicochemical parameters as temperature, salinity, pH and dissolve oxygen, as well as nutrients like nitrogen, phosphorus and silicon. In addition during the 2023 more than 45 specimens of the Pacific oyster *Magallana gigas* (Thunberg, 1793) (= Crassostrea gigas) were laboratory tested. The samples were collected from ten localities of wild oyster colonies along the Southern Bulgarian Black Sea coast. As a result, clinically important vibriones were isolated, characterized and confirmed by MALDI-TOF MS as: *Vibrio parahaemolyticus, V. alginolyticus, V. orientalis, V. vulnificus, V. aestuarianus, V. anguillarum, V. harveyi.* Of them, for the first time *V. aestuarianus* was isolated from the Bulgarian Black Sea area.The diversity of *Vibrio* representatives as well as the presence of *V. vulnificus* and *V. parahaemolyticus,* in Bulgarian Black Sea aquatory indicates that health risk exists not only for marine animals but also for humans, especially during summer season when the sea water temperature exceeds 20–25°C, favoring the development of *Vibrio*. The role of climate change in spread of pathogenic vibriones is also commented.

Keywords: *Vibrio spp*; Bulgarian Black Sea area; animal pathogens; Pacific oyster; health risk

Diel Variation in Bottom-trawl Species Diversity in İzmir Bay (the Central-Eastern Aegean Sea)

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Abstract

Light intensity is a critical environmental variable affecting the presence, abundance and behaviour of many organisms throughout the diel cycle. Depending on changing light levels by the time of day, possible changes in the activity and position of the demersal organisms may affect their catchability to the bottom trawl. From this point of view, the effects of the diel period on bottom-trawl species diversity were investigated during seven experimental surveys carried out by R/V K. Piri Reis within the same locality at depths ranging between 50 and 58 m in İzmir Bay. A total of 56 trawl samplings were performed that covered the morning, noon, afternoon, dusk, early night (between dusk and midnight), midnight, late night (between midnight and dawn) and dawn periods of the day in each seasonal survey. Overall, 64 species were captured, including 3 crustaceans, 8 cephalopods, 9 cartilaginous fish, and 44 bony fish. The number of species by the trawl hauls ranged from 12 to 31 species, and Shannon-Wiener diversity index H'(loge) ranged from 1.006 to 2.861. Although it was generally observed that the number and diversity of species in trawls towed during the daylight periods were relatively higher than in trawl samples towed during twilight and night periods, no clear diel pattern was found.

Keywords: Bottom-trawl, diel, day period, dark period, twilight, İzmir Bay.

Antibiotic resistance risk is growing issue for aquaculture

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Aquaculture has become a vital sector in global food production, supplying a significant portion of the world's seafood. However, the intensive nature of aquaculture, characterized by high stocking densities and close quarters among aquatic organisms, creates an environment conducive to the rapid spread of pathogens. As a response, antibiotics are commonly employed in aquaculture for disease prevention and treatment. In crowded aquaculture environments, such as fish farms, bacteria and other pathogens can easily spread, causing infections among aquatic organisms. Antibiotics are used to prevent and control these infections to ensure the health and well-being of the farmed fish or other aquatic organisms. However, their excessive or inappropriate use can contribute to antibiotic resistance in bacteria and have adverse effects on the environment. Continued research and collaboration among stakeholders will be essential to navigate the complexities of antibiotic use in aquaculture and ensure the long-term viability of this vital food production sector. In this review, the main antibiotics used in fish, methodologies used for the detection of antimicrobial resistance (AMR) to antibiotics screened/applied in aquaculture systems, risks for the development of AMR and alternatives to antibiotics are discussed with a simple literature review.

Keywords: Antibiotics, Antibiotic resistance, Aquaculture, Fish

Aquaculture and environment: perceptions of pollution and sustainability within the local community's context in the Croatian Adriatic Sea

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Abstract

Aquaculture research, in the Croatian Adriatic Sea context, is primarily based within natural, technical and economic sciences and there is an evident lack of research from social perspective as well as emphasis of sustainability and (sociological) environment issues. Development of mariculture, as a dominant part of aquaculture sector, significantly impact the lives of the coastal communities as well as environment. The Croatian mariculture sector, which from year to year records an increase in number of sites and total produced quantities, consists of three main species: tuna, white fish and shellfish. This paper, based on the sociological approach, aims to investigate how local communities perceive pollution from aquacultural sites as well as sustainability of different types of aquaculture production in Croatia. The aim of this approach is to explore how people on the coast frame the problems which they connect with aquaculture but also to capture the perspective from those in aquaculture sector (aquaculture managers/consultants). By relying on sociological approach, this research explores the different types of environmental impact of aquaculture production, perceptions of pollution and sustainability of tuna farming, white fish cultivation and shellfish farming in the Croatian Adriatic. Data was collected via interviews as a qualitative collection method, on 4 different locations in Croatian Adriatic region, with different types of aquacultures. With this approach, an attempt is made to explore how the development of mariculture produces different contradictions and conflicted perceptions regarding the environmental impact and sustainability. Better understanding of this problem could allow more sustainable future aquatic research.

Keywords: Aquaculture, Environment, Pollution, Sustainability, Adriatic Sea

Potential Nutritional Benefits of US-Caught Crab Species Through Panel Data Analysis Forecasting 1950–2021

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Abstract

In this study the data of 12 different crab species obtained throughout the USA between 1953 and 2021 were used. In the light of the data obtained after compiling the nutritional values of the related species. estimations were made on the data between 2007 and 2021 by applying the panel data analysis method to the data. The aim of these estimations is to determine the nutritional values of the crabs to be obtained in the coming years. based on the crab species grown or caught. Being able to determine this is important in terms of decreasing food resources and increasing population. As a result of the study. the estimated values were compared with the actual values and it was emphasized that it would be appropriate to make an estimate over the values closest to the actual values and to work on whether these estimates will meet the increasing food supply in the world.

Keywords: Crab species, estimation method, nutritional value, panel data analysis.

Carrageenan Yield and Quality of Raw Dried Seaweeds from Tawi-Tawi, SW Philippines

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Abstract

The commercial farming of red seaweeds has substantially grown over the past 50 years to meet the global demand for carrageenan. Carrageenan is used as a thickening, gelling, and stabilizing agent in the food, pharmaceutical, cosmetic, and biotechnological industries. The three most commonly cultivated seaweed species in the Sulu Archipelago are *Kappaphycus striatus*, *K. alvarezii*, and *Eucheuma denticulatum*. Carrageenan yield and quality are influenced by seedling quality and post-harvest handling processes. We assessed the carrageenan yield and quality of raw dried seaweed (RDS) collected from farmers and traders in Tawi-Tawi. We measured the moisture content (MC) and foreign matter content (FMC) of RDS. We then extracted native and alkali-treated carrageenan from these samples and analyzed their rheological properties. The MC and FMC of RDS from farmers and traders ranged from 34-42% and 4-13%, respectively. The carrageenan yield, viscosity, syneresis, and gel texture of the RDS ranged from 23-33%, 4-32 cP, 20-40%, and 32-113 g/cm², respectively. The results of this study show that the RDS from Tawi-Tawi have low quality and do not meet the national standards set by the Bureau of Fisheries and Aquatic Resources (BFAR).

Keywords: *Kappaphycus* spp., seaweed farming, carrageenan yield, Tawi-Tawi, “ice-ice” disease.

An indigenous small-scale recirculating aquaculture system for high-density fish culture: Sustainability in Action

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Abstract

The United Nations (UN) has put forth 17 sustainable development goals (SDGs) and is committed to using aquaculture to achieve these goals. We have developed and implemented an indigenous recirculating aquaculture system (RAS) for high-density fish culture with the objectives of providing nutritional security and empowering the financial independence of women in aquaculture, helping them contribute towards family income. The system consists of a culture vessel (90 m3) accompanied by venturi air injectors to provide aeration and remove sludge, and nitrification through trickling filters. The analysis of the system performance showed an annual biomass production of 2306 ± 83.45 kg. Out of the 109 systems deployed in India, 98 were successfully managed by women accounting for 90% of the total units. Through this achievement, we could align with the UN-SDGs namely, No Poverty; Zero Hunger; Good Health and Well-Being; Gender Equality; Decent Work and Economic Growth; Reduced inequalities; Responsible Consumption and Production; and Life Below Water.

Keywords: recirculating aquaculture system (RAS), United Nations Sustainable Development Goals (UN-SDGs), small-scale aquaculture

The Anesthetic Effects of Lemon Peel Oil on Rainbow Trout (*Oncorhynchus mykiss* Walbaum, 1792)

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Abstract

The objective of this study was to investigate the effects of lemon peel oil as an anesthetic agent on rainbow trout (*Oncorhynchus mykiss*), which is intensively produced in Türkiye. For anesthesia efficacy evaluation, rainbow trout with an average weight of 51 g were exposed to different concentrations of lemon peel oil (500, 1000, 2000, 3000, 4000, and 5000 µL/L). Induction and recovery times were recorded by using a digital stopwatch for each fish. According to the results, it was observed that there were significant differences between the anesthetic substance concentration values, and as the concentration of lemon peel oil increased, the induction time decreased ($P<0.05$). However, it was determined that, as the concentration of the anesthetic agent increased, the time it took for the fish to recover from anesthesia shortened ($P<0.05$). As a result of the experiment, it was observed that the fish entered anesthesia in less than 3 minutes at a dose of 5000 µL/L lemon peel oil and recovery time from anesthesia in less than 5 minutes. Our findings indicate that 5000 µL/L is the best concentration of lemon peel oil for rainbow trout in our research.

Keywords: Anesthetic agent, anesthesia, induction time, recovery time

Interactions Between Maritime Shipping and Offshore Aquaculture

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Abstract

The aim of this research is to investigate the reciprocal influences of offshore aquaculture and maritime shipping activities for providing granular guidance to decision makers by presenting compilations on mutual expectations of maritime shipping industry and offshore aquaculture facilities. In this research, several questionnaires and semi-structured interviews are conducted with ship masters, port authorities and aquaculture industry representatives operating along the coastline of Türkiye. The obtained results reveal that both sectors contain elements which have potential to hinder each other's growth and more comprehensive and integrated approaches should be adopted for future policies, regulations and standards.

Keywords: Maritime Shipping, Offshore Aquaculture, Semi-structured interviews, Workforce insights

Importance and Control of *Morganella morganii* in Seafood

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Abstract

Morganella morganii is a Gram-negative bacterium in the Enterobacteriaceae family and is an important producer of histamine, which is known to be associated with seafood. Histamine poisoning is a common illness worldwide caused by the consumption of seafood containing histamine. Histamine, which is an important bacterial metabolite, especially in fish belonging to the Scombridae family, is formed by decarboxylation of free histidine, which is found in high amounts in the muscle tissues of these fish. Histamine poisoning is caused by the consumption of fresh, frozen, or canned fish containing high levels of histamine. It is very difficult to remove histamine from seafood because it remains stable after heating and freezing. Therefore, microbial (bacteriophage) control of histamine-producing bacteria in seafood is one of the best methods to prevent histamine poisoning.Bacteriophages are bacterial viruses that infect and lyse bacterial cells. The antimicrobial potential of phages has become more important following the emergence of antibiotic-resistant bacteria. There are limited studies on the use of phages to inhibit the growth of histamine-producing bacteria. The use of bacteriophages as biocontrol agents is noteworthy as an alternative approach for the control of both human and foodborne pathogens due to the increased resistance of pathogenic microorganisms to antimicrobials and the host specificity of phages. The purpose of this review is to provide information on the use of *Morganella morganii* in the seafood sector. The information about the use of *Morganella morganii* in the seafood sector has been prepared by referencing national and international articles and theses.

Keywords: *Morganella morganii*, Histamine, Bacteriophage, Seafood

Study on bioaccumulation and some physiological effects of nanoplastic on Goldfish (*Carassius auratus*)

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Abstract

Nanoplastics are emerging environmental contaminants, raising significant concerns about their potential toxicity in aquatic organisms. Histopathological examination is a valuable tool for diagnosing the effects of such pollutants on fish gills. This study investigated the accumulation, absorption, and toxic effects of polystyrene nanoplastics (PS-NPs) on goldfish gill tissue. Fluorescent and non-fluorescent PS-NPs of two different sizes were used. After acclimation, the fish were exposed to constant concentrations (30 mg/L) of both fluorescent NP sizes for varying durations (24, 48, and 72 h). Fluorescent microscopy quantified bioaccumulation of different-sized fluorescent PS-NPs in gill tissue. Subsequently, the fish were exposed to non-fluorescent PS-NPs at different concentrations for 28 days to assess histopathological changes using classical histology. Exposure to both fluorescent PS-NP sizes (8 and 0.25 μm) for 7 days at 30 mg/L resulted in their accumulation in gill tissue, with levels increasing over time. The highest concentrations detected were 0.701 μg/g and 0.272 μg/g dry gill weight for 8 μm and 0.25 μm particles, respectively. Histopathological analysis revealed various lesions in both size groups compared to controls, including lamellar aneurysm, secondary blade epithelial bulge, lamellar deviation, secondary blade connection, lamella shortening, and deposition of unidentified material. Notably, the severity of these lesions varied depending on the exposure concentrations. This study demonstrates the accumulation of nanoplastics in goldfish gills and their impact on gill tissue structure. However, the full extent of their toxic effects remains unclear. Importantly, no comparable findings in goldfish have been reported previously, highlighting the need for further research in this area.

Keywords: Nanoplastic, Microplastic, Polystyrene, Pollution, Goldfish

Improvement effects of vitamin C on hematological indices and DNA breakage in Common carp (*Cyprinus carpio*) after exposure to zinc oxide nanoparticles

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Abstract

The rapid growth of nanotechnology has led to an increase in the number of types and applications of nanomaterials. However, the potential release of these materials into the environment raises significant concerns for both human health and ecological well-being. This study examined the effects of zinc oxide nanoparticles (ZnO NPs), an emerging environmental pollutant, on the hematological indices in common carp (*Cyprinus carpio*). We further explored the potential of vitamin C supplementation to mitigate DNA damage and improve hematological parameters following nanoparticle exposure. Nine treatment groups were established, each with three replicates. Two concentrations of ZnO NPs (40 and 80 mg/L) and two levels of vitamin C supplementation (400 and 800 mg/kg) were employed. Following the experimental period, blood and tissue samples were collected on days five and ten days for analysis of various factors, including erythrocyte and leukocyte indices. DNA extraction was performed using a commercially available Cinapure DNA kit, following the manufacturer's instructions. DNA gel electrophoresis was conducted and the resulting gels were photographed for analysis. Percentage of DNA breakage was determined using the average weighted intensity of bands. The results revealed a significant decrease in red blood cell count, hemoglobin concentration, and hematocrit, while the white blood cell count displayed a marked increase in fish exposed to ZnO NPs. The most pronounced DNA damage, as evidenced by gel electrophoresis, was observed in the liver and gill tissues of fish exposed to the highest concentration (80 mg/L) of ZnO NPs on day five. These findings suggest a strong influence of ZnO nanoparticle concentration, vitamin C supplementation level, and exposure duration on the observed effects. Overall, dietary vitamin C demonstrated a non-specific immune-stimulatory effect in common carp, contributing to improved hematological indices, reduced tissue DNA breakage, and potential mitigation of the detrimental effects of ZnO NPs on hematological parameters and DNA integrity.

Keywords: Resistance Improvement, Hematology, DNA breakage, ZnO nanoparticles.

Emerging contaminants oxidation with ozone.

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Abstract

Preserving water quality is essential in aquaculture to increase farm yields and protect consumers and the environment.

Emerging contaminants are substances which, based on their (eco)toxicity, potential effects on human health and their presence and persistence in the environment, have recently been included in regulations or are candidates to be included in future. This is a dynamic list to which new substances are always added, such as drugs for human and veterinary use (e.g. antibiotics and hormones), endocrine modifiers and disruptors, perfluorinated compounds, psychoactive substances used by humans (e.g. drugs, nicotine), toxins produced by cyanobacteria (e.g. microcystin) and others. Emerging contaminants can reach aquaculture through anthropogenic addition or inlet water and may cause harmful effects, antibiotic resistance, and adversely affect the farmed fish species. Furthermore, the discharge of aquaculture effluents into the environment may contribute to introducing emerging contaminants into the environment. Conventional processes are not designed to deal with Emerging contaminants; this article presents the results of a pilot plant for the oxidation of emerging contaminants with ozone. Ozone is a gas with three oxygen atoms (O3). Ozonation is a water treatment method where ozone is generated on-site and introduced into water to eliminate a wide range of organic compounds and microorganisms. The transformation of oxygen into ozone occurs with the use of energy. Inside the ozone generator vessel, ozone is produced from oxygen in the feed gas through a silent electric discharge (non-thermal plasma). Ozone is dissolved in the water. It produces a direct oxidation of the pollutants.

Keywords: Ozone, contaminants, aquaculture, environment, oxidation

Impact of multiple stressors on the resilience of Mediterranean zooplankton communities

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Abstract:

Zooplankton communities play a crucial role in the aquatic ecosystem, as a vital link between primary producers and higher trophic levels. However, these delicate organisms are increasingly facing numerous stressors due to anthropogenic activities and environmental changes. In this essay, we will delve into an in-depth analysis of how responses to multiple stressors affect the resilience of zooplankton communities. By examining how these stressors interact and the subsequent implications for zooplankton, we can gain valuable insights into the vulnerability of these essential organisms.

Keywords: Zooplankton communities, Resilience, Environmental stressors.

Investigation of the Utilization Potential of *Haematococcus* sp. *(Flotow, 1844)* in Carbon Quantum Dot Production

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Abstract

Quantum dots (QDs) are considered as the next generation carbonaceous materials used in many fields due to their size under 10 nm size with their advantageous properties such as stable photoluminescence, broad excitation spectra, multicolor fluorescence, surface tunable functionalities and water solubility. The use of toxic precursors for the preparation of ODs derived from semiconductors such as CdS and CdSe or alternative metal photoluminescent nanomaterials such as gold nanodots and silver nanoclusters and their negative properties such as leakage of toxic metal ions from QDs into biological systems, low quantum yield (QY) and poor photostability have led to the search for new raw materials. At this point, studies have shown that carbon quantum dots (CQDs) are potential alternatives to conventional toxic metal-based semiconductor quantum dots, especially in biomedical applications, as they contain non-toxic elements and exhibit low cytotoxicity, excellent biocompatibility and lower environmental hazards. Therefore, in this study, the potential of *Haematococcus* sp., one of the green microalgae species, in CQD production was investigated. For this purpose, for solvent optimization in CQD production, 2 different solvents (8M sulfuric acid and 8M urea) were used and reacted with different amounts of *Haematococcus* sp (10,20,40,80 and 160 mg) and autoclaved at 180 ºC for 2.5 hours. In addition, microwave experiments were carried out with 6 different solvents (Distilled Water, DMSO, Phosphoric acid, Sulfuric acid, Urea and Ethylene Glycol) by reacting with fixed amounts of dry and powdered *Haematococcus* sp. Microwave experiments, which are known and widely used as a conventional device, were found to be unsuccessful as a result of excessive evaporation.

Keywords: *Haematococcus* sp., Quantum dots, Autoclave, Reaction, conventional

1.Introductıon

Carbon dots (CDs), which are spherical nanoparticles with dimensions below 10 nm, as a new member of the carbonaceous material family, have been used since their discovery by change due to their advantageous properties such as stable photoluminescence, broad excitation spectra, multicolor fluorescence, surface tunable functionalities, and water solubility. has received great attention.

Carbon quantum dots are nanoparticles with fluorescence activity; that is, they emit light of specific wavelengths after absorbing an initial radiation. This fluorescence activity is evidence of the quantum confinement effect that can occur in nanosized systems. Traditionally, carbon quantum dots have been synthesized from heavy metals such as Cd and Pb, but the synthesis of carbon quantum dots (CQDs) using different carbon sources is an innovative approach. Marine polysaccharides have also been reported to be used as carbon sources for the synthesis of CQDs.

The environmental friendliness and unique biocompatibility, biodegradability and non-toxicity properties of biopolymers are important for their use in the field of nanotechnology. Organisms in aquatic ecosystems also represent an important source in the production of nanoparticles, such as polymers that can be obtained from natural sources such as plants, animals, microorganisms and agricultural wastes (Baranwal et al., 2022; Jing et al., 2021). Major among these is algae. For the development of new nanomaterials, including nanofibers (Iacob et al., 2020), nanoparticles (Yosri et al., 2021), nanocrystals, nanogels (Can & Sahiner, 2021), as well as carbon quantum dots (Torres et al., 2023). They have high potential for use.

Nanomaterials have a significant contribution to the advancement of technology in fields such as food, agriculture, energy and medicine. Nowadays, more studies are being carried out in this field. delivery methods, biopolymer nanoparticles are used in various medical and healthcare fields such as bioimaging and Biosensing. They are also used in edible films, wastewater treatment, fluorescent biosensors and packaging materials.

Haematococcus sp. (Flotow 1844) is a freshwater species from the Chlorophyta family. This species is known for its content of astaxanthin, a powerful antioxidant. Astaxanthin is important in aquaculture and cosmetics. Additionally, this microalga is rich in astaxanthin, a red antioxidant that acts under high stress. Thanks to this compound, *Haematococus* gives color to its enemies and is effective in the survival phase. One of the pigments that gives flamingos their pink color is astaxanthin. This pigment belongs to the group of carotenoids, which includes more than 600 yellow, orange, pink and red colors. It is of interest for the industrial production of this antioxidant.

Haematococcus is known for its high antioxidant content and is used not only in cosmetic products but also in other areas.

- Antioxidant: *Haematococcus* produces astaxanthin, a powerful antioxidant. This substance can reduce cellular damage by fighting free radicals.

- Anti-inflammatory: Astaxanthin can reduce inflammatory processes and support the immune system.
- Antimicrobial: Components of *Haematococcus* can be effective against microbes.
- Skin Protection: Astaxanthin supports skin health and protects skin exposed to sunlight.
- Cancer Treatment and Prevention: Some studies show that astaxanthin may prevent the growth of cancer cells.
- Eye and Nervous System Health: Astaxanthin supports eye health and may protect against neurodegenerative diseases.
- Immune System Stimulation: Astaxanthin can strengthen the immune system.

The aim of this study is to grow *Haematococcus* sp. in the laboratory and produce carbon quantum dots with the resulting dried samples. This study aims to produce highly efficient carbon quantum dots obtained from these algae species with the most suitable solvent and the most suitable production technique.

2. Materials and Methods

2.1. Production of *Haematococcus* sp.

In this study, which will be carried out under laboratory conditions, E.Ü. *Haematococcus* taken from the Plankton Culture collection of the Faculty of Fisheries was used. In addition, the room temperature was adjusted to 23±2 ºC with the help of an air conditioning device as the optimum breeding condition for the development of the culture. The average pH range is 8.2-8.7, and cultures were carried out under laboratory conditions with constant illumination at a light intensity of 27 umol $m^{-2}s^{-1}$

Optimal *Haematococcus* Medium (OHM) nutrient medium, which is suitable for *Haematococcus* species, was used as the culture medium.Cultures were grown in an 18/6-hour light-dark cycle with constant shaking. The stock solution is g/l distilled water in this medium; Optimal *Haematococcus* Medium has been added.

Optimal *Haematococcus* Medium;

KNO3	0.41
Na2HPO4	0.03
MgSO4.7H2O	0.246
CaCl2.2H2O	0.11
Fe(III)citrate.H2O	2.62
CoCl2.6H2O	0.011
CuSO4.5H2O	0.012
Cr2O3	0.075
MnCl2-4H2O	0.98
Na2MoO4.2H2O	0.12
SeO2	0.005
Biotin	25
Thiamine	17.5
B12	15

2.2.Harvesting *Haematococcus* sp.

Each of the cultures was harvested according to their optical density at the end of the logarithmic phase and the beginning of the pause phase using a vacuum filtration device using a plankton cloth of appropriate mesh size. The obtained wet biomass was dried in the oven below 40 ºC. After the dried samples were passed through the grinder and turned into powder, the dry biomass was then divided into coarse pieces with the help of a mixer, then turned into homogeneous and powdered form with the homogenizer and placed in plastic bags and stored at 4ºC until the quantum dots were obtained.

2.3.Production of Carbon Quantum Dots

Algae were dry-powdered for the production of carbon quantum dots and used as precursors for the synthesis of fluorescent CQDs. For solvent optimization of carbon quantum dots, microwave experiments were carried out by reacting them with fixed amounts of dry and powdered *Haematococcus* using Distilled Water, DMSO, Phosphoric acid, Sulfuric acid, Urea and Ethylene Glycol.

The resulting 6 different reactions were heated in the microwave for a limited time and temperature. Measurements were taken on a fluorescent spectrophotometer to detect the formation of carbon quantum dots.

Before the characterization studies of the obtained carbon quantum dots, blank experiments were carried out using the same amount and solvents. The fluorescence yields of all microwave and blank samples were measured.

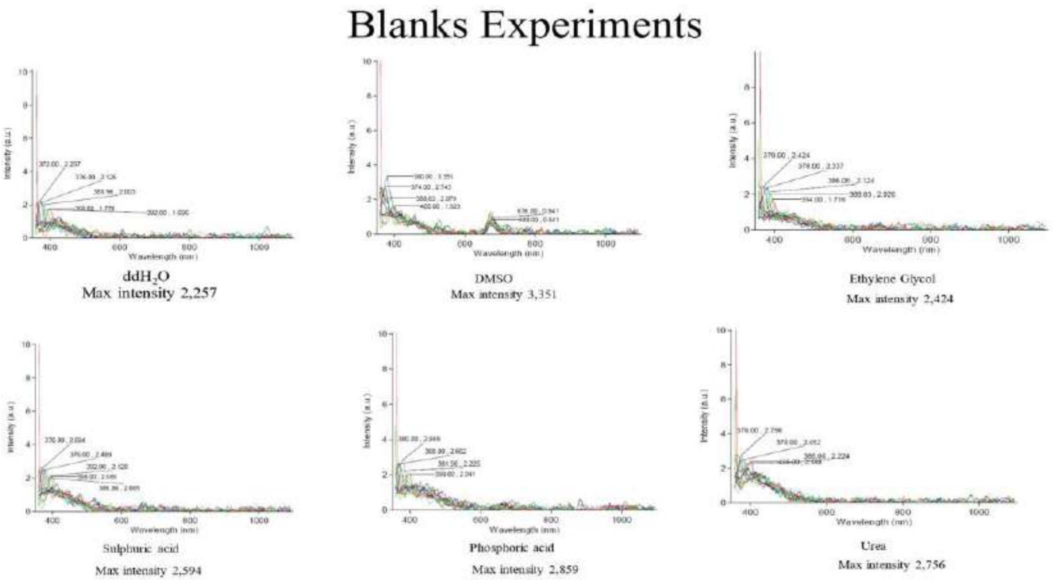

Figure 1. Blank Experiment's Results

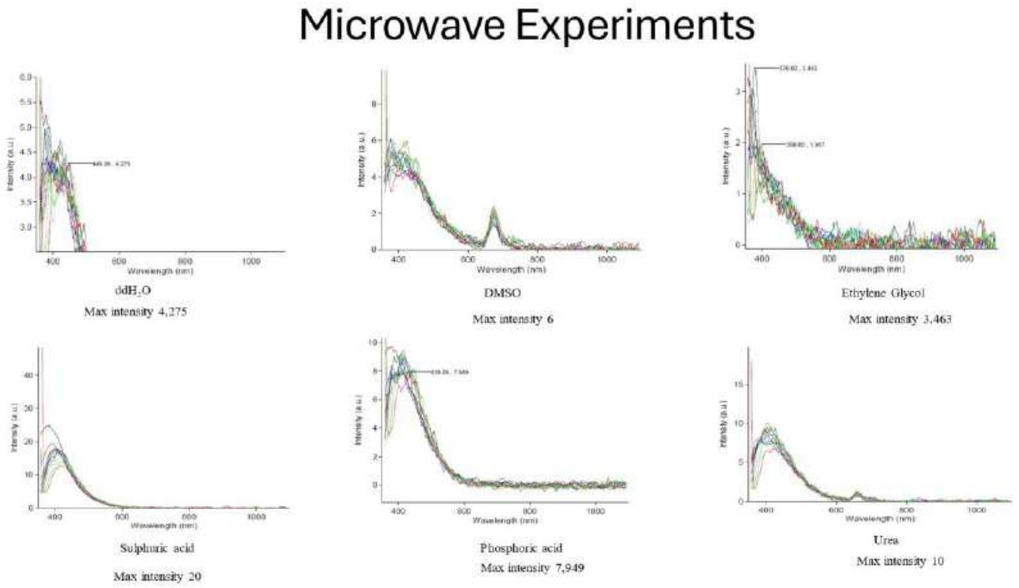

Figure 2. Microwave Experiment's Results

Table 1. Carbon Quantum Dots Production Results

Solvents	Blank	Microwave	Difference
ddH_2O	2,257±0,0003	4,275±0,0005	2,018±0,0002
DMSO	3,351±0,0005	6±0,0002	2,649±0,0003
Ethylene Glycol	2,424±0,0002	3,463±0,0003	1,039±0,0002
Sulphuric acid	2,594±0,0005	20±0,0004	17,406±0,0005 ★
Phosphoric acid	2,859±0,0003	7,949±0,0006	5,09±0,0004
Urea	2,756±0,0004	10±0,0001	7,244±0,0002 ★

It was determined that the most effective solvents in microwave experiments were urea and sulfuric acid. Therefore, autoclave experiments were conducted with 8M urea and 8M sulfuric acid using different amounts of algae at 180 ºC for 4 hours.

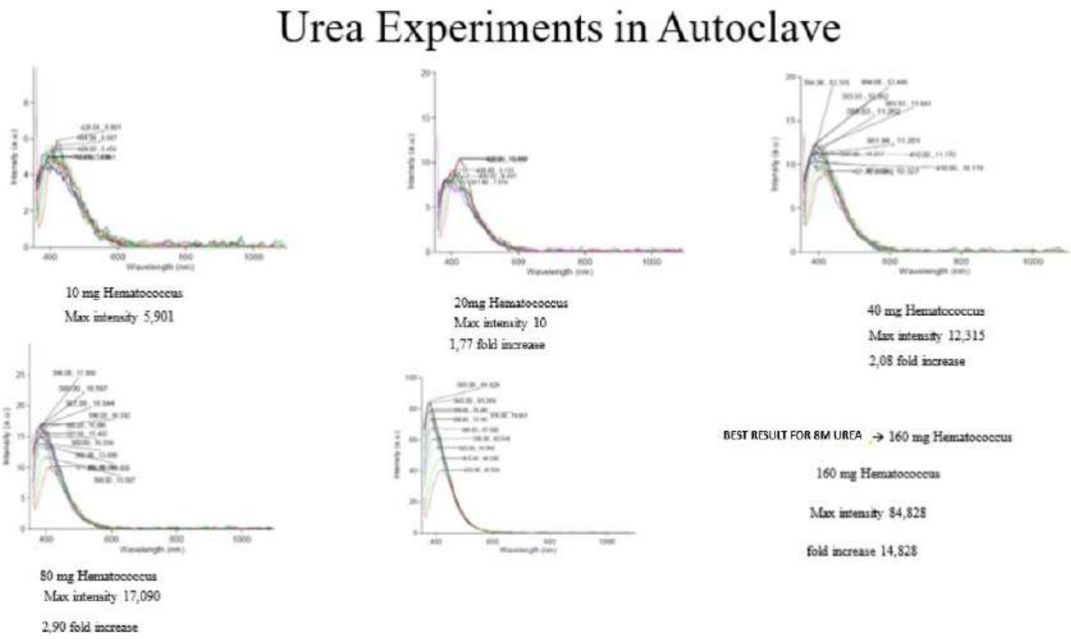

Figure 4. Microwave Experiment's Results with Urea

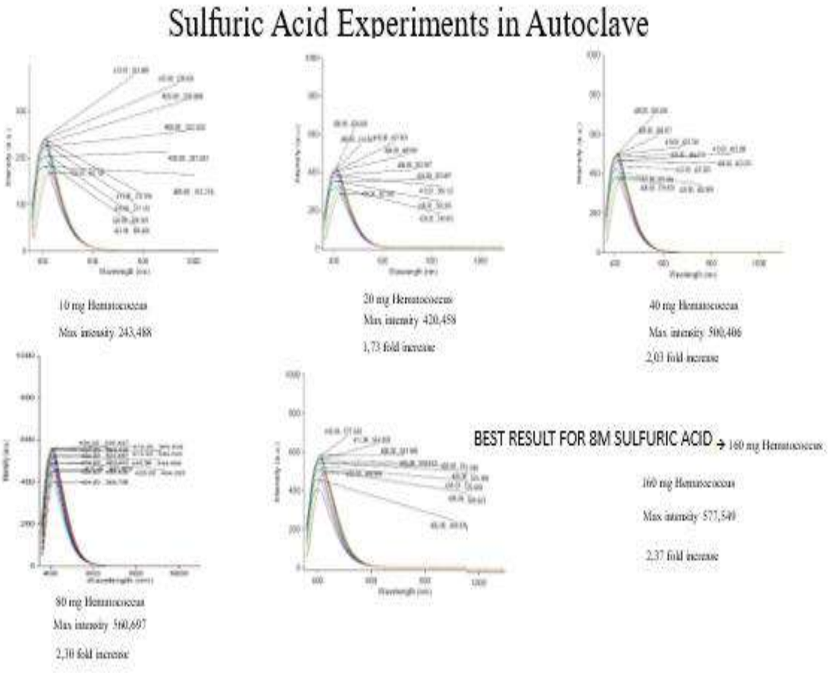

Figure 5. Microwave Experiment's Results with Sulfuric acid

3.Results and Discussion

Algae were successfully cultured.
In microwave experiments, the best results were obtained from quantum dots prepared with sulfuric acid and urea compared to untreated samples. Therefore, autoclave experiments were conducted with these two solvents. It was observed that the fluorescence intensity increased as the amount of algae added increased. In samples where 160 mg Hematococcus was added, a 2.37-fold increase was observed for sulpjhiric acid , and a 14.828-fold increase for urea. Therefore, it was found that the optimal conditions for obtaining carbon quantum dots from Hematococcus are using 8 M urea as the solvent and autoclaving at 180°C for 4 hours.
Green synthesis of metal nanoparticles using microalgae has been reported by other researchers (Mutaf et al., 2012). Another study focused on the synthesis and photoluminescence of carbon quantum dots from red onions. To determine the ideal solution at 250 mL, they looked at its characteristics and carried out concentration measurements. A mixture of µl/4950 µl of pure water has been reported to be present (Biçer & Bilgioğlu Biçer, 2020).
In a different investigation, carbon was initially extracted from Malva Sylvestris, a wild plant that grows naturally. Made by green synthesis in a water environment using the microwave method, which is an affordable process, quantum dots (CQDs) are environmentally benign, effective, and simple to apply (Mahmood, 2019). Several algal species have been the subject of studies using CQD (Pescheck et al., 2016).

Conclusion

For the first time, carbon quantum synthesis from Hematococcus has been accomplished utilizing the microwave method and autoclave method. This work is a preliminary analysis of the optimization experiments of the Synthesis of Carbon Quantum Dots from Hematococcus using these two approaches. Because there is inadequate information, comparing data from literary studies is inappropriate. This work is considered promising as a pilot study for further research on carbon quantum synthesis from algae.

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Effects of Different Ratios of Groundnut Meal Supplemented Diets on Digestive Enzymes and Growth Parameters of Rainbow Trout (*Oncorhynchus mykiss* Walbaum, 1792)

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Abstract

In this study, the effects of diets supplemented with different ratios of peanut meal instead of soya meal and commercial feed on growth performance, fatty acid compositions, mineral matter contents and digestion enzymes of rainbow trout, *Oncorhynchus mykiss*, were comparatively evaluated under controlled conditions for 12 weeks. For this purpose, 3 experimental and 1 control feed (0% PM) containing 50% (PM_{50}), 75% (PM_{75}), and 100% (PM_{100}) peanut meal with a protein content of 45% were prepared. In the study using 2 control groups, the 1st control group was fed with a commercial feed (CF), the 2nd control group was fed with a control feed containing 0% (K) peanut pulp (groundnut meal) and the other groups were fed with the experimental feeds. At the end of the experiment, the best growth was determined in the K group, followed by the groups fed with the diets supplemented with PM. In terms of fatty acid compositions, there was a high similarity between the experimental and CF fed groups. It was determined that the fatty acid compositions of the groups fed with experimental feeds were more balanced. It was found to be quite high, especially when DHA and EPA ratios were compared. Again, mineral matter contents were higher in the group fed with PM_{100} feed than the other groups. Digestive enzyme activities of pepsin, amylase, lipase and trypsin were determined from stomach and intestine. The lowest amylase activity in the intestines of the fish was found in CF and K groups, and the highest activity was found in PM_{100} group ($p<0.05$). The pepsin activity in the stomach of the fish fed with PM_{50} group feeds was significantly higher than that in the control group and at the beginning of the experiment ($p<0,05$). The lowest trypsin activity was found in CF group ($p<0,05$).

Keywords: Mineral matter contents, fatty acid composition, amylase, trypsin, pepsin

Bycatch/ Discard of Turkish Marine Fisheries and Their Impact on Sustainability

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Abstract

Determining bycatch and discards in marine fisheries is critically important for implementing measures to ensure sustainable fishing. High levels of bycatch and discards lead to the degradation of marine ecosystems, reduction in species diversity, and economic losses. Methods such as using selective fishing gear, regulating fishing areas and seasons, minimum size limits, quotas and capacity control, technological advances, and social cohesion can reduce bycatches. When these methods are not used, most fishermen catch non-targeted species and then release them back into the sea when they are dead or dying. This study aimed to review the research on by-catch and discards in Turkish marine fisheries and to highlight their importance in terms of sustainability. Measures should be taken to minimize by-catches, reduce the number and quantity of species discarded, and apply ecosystem-based fisheries management to ensure the sustainability of marine ecosystems and fisheries.

Keywords: Bycatch, discard, sustainability, incidental catch, catch rate.

Introduction

Commercial fishing has a major impact on marine systems and requires urgent and comprehensive management, as it affects both marine populations and ecosystems worldwide (Ortuño et al., 2017). Target and bycatch values should be taken into account during fishing certain assessments should be made in this way, and the best use of fishing gear should be ensured (Acarlı et al., 2022). Bycatch and discard are an important problem for global fisheries and are considered unnecessary mortality and waste of resources (Saygu et al., 2014). It is important to solve the bycatch and discard problem to minimize food waste and increase seafood production.

The catch from fisheries is evaluated in two components: target species and non-target species. Non-target species are divided into 'bycatch', which includes commercially important species caught unintentionally, and 'discard', which consists of species that are not commercially important or are of an uneconomic size for the target species (Cook, 2003). The use of fishing gear can lead to the simultaneous capture of multiple species. In this case, economically valuable species, non-economically important species, and even small individuals of economically valuable species may be accidentally caught (Hall et al., 2000).

The problem of bycatch has been inherent in fisheries for centuries. Although interest in bycatch dates back to the 1970s, understanding and measuring bycatch has become widespread in research over the last three decades. While there are limited studies on bycatch caused by small-scale fisheries in the Mediterranean Sea, it has been reported that the amount of bycatch varies according to the fishing gear used and the fishing area (FAO, 2018). According to FAO (United Nations, Food and Agriculture Organization) data, the average annual amount of seafood caught and landed in the world between 1988 and 1990 was 77 million tons, while the amount of discards thrown back into the seas in the same period was 27 million tons/year. In 1998, the total amount of landed catch remained at 77 million tons, while the annual discard amount was calculated as 19 million tons. In 2001, total landings reported that the catch increased to 84 million tons while discards decreased to 7 million tons (FAO, 2004). In their study, Perez et al. (2019) estimated the annual discards to be 9.1 million tons between 2010 and 2014. This latest comprehensive study includes more observer programs and initiatives such as electronic monitoring, electronic logbooks, and smartphone reporting. Discards were estimated at around 230,000 tons for the Mediterranean and 45,000 tons for the Black Sea (FAO, 2018; Sala et al., 2015; Sanchez et al., 2007; Tsagarakis et al., 2014; Tzanatos et al., 2007). The slight declines reported in discard rates in Mediterranean and Black Sea fisheries may be linked to the introduction of landing obligations in European countries and the subsequent adoption of technical and spatial restrictions (FAO, 2023). Non-native invasive species such as lionfish (*Pterois miles*), pufferfish (*Lagocephalus sceleratus*), and striped piggy (*Pomadasys stridens*) have a major role in the higher discard rates (usually above 40 percent), especially in the Eastern Mediterranean, where Türkiye is located (Acarlı et al., 2022; Cerim et al., 2022; FAO, 2023).

This study aims to review the research on bycatch and discards in Turkish marine fisheries and to highlight their importance in terms of sustainability.

Materials and Methods

Electronic search engines were searched using keywords (target catch, bycatch, discard), and scientific studies on fisheries conducted off the coast of Türkiye that included at least one of these words in the title of the study were included. If target catch, bycatch, and discard rates were specified in the studies, these values were taken, if not, they were calculated using the following formulas (Matsuoka, 1999; Sparre and Venema, 1998).

$Rh = Dh / C$

$Rt = Dt/C$

$Rı = Dı / C$

Dh indicates target catch (g); C, total catch (g); Rh, target catch rate; Dt, bycatch (g); Rt, bycatch rate; Dı, discard catch (g) and Rı, discard rate)

The obtained ratios were tabulated and compared based on fishing gear.

Results

It was determined that studies on bycatch and discards in Turkish seas were conducted between 2004 and 2023. Of these studies, 14 focused on bottom trawls, 3 on purse seines, 3 on beam trawls, 2 on longline sets, and 8 on gillnets/trammel nets. When analyzed according to the seas where they were carried out, there were 2 studies in the Marmara Sea, 8 in the Black Sea, 8 in the Aegean Sea, and 11 in the Mediterranean Sea.

Target catch, bycatch, and discard rates of bottom trawl nets used in the Turkish coasts are presented in Figure 1 according to the study regions.

The highest bycatch rate was recorded in Mersin-Taşucu Bay in the Mediterranean Sea with a total of 94%, including 17% bycatch and 77% discards (Soykan et al., 2006). The lowest bycatch rate was recorded in the Ordu-Samsun coasts in the Black Sea with a total of 23%, including 7.9% bycatch and 15.1% discards (Soyer, 2018).

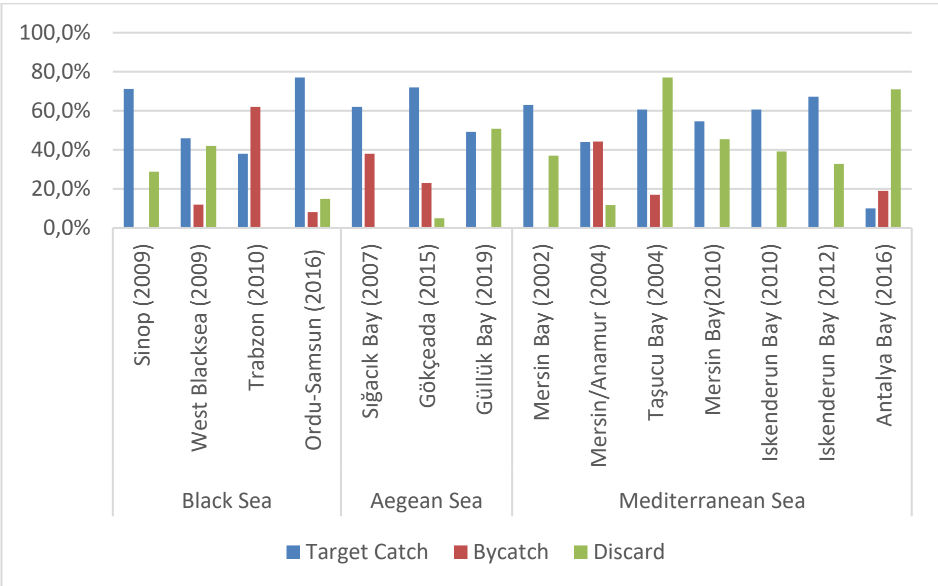

Figure 1. Target, bycatch and discard rates of bottom trawl nets used in the Turkish coasts *(Sinop 2009- Aksu et al., (2023); West Blacksea 2009- Ceylan et al., (2013); Trabzon 2010- Kasapoğlu et al., (2021); Ordu-Samsun 2016- Soyer, (2018); Sığacık Bay 2007- Soykan, (2011); Gökçeada 2015- Acarlı et al, (2022); Güllük Bay 2015- Cerim et al, (2022); Mersin Bay 2002- Özbilgin et al., (2006); Anamur 2004- Malal (2006); Taşucu Bay 2004- Soykan et al., (2006); Mersin Bay 2010- Eryaşar (2011); Iskenderun Bay 2010- Yemişken, (2011); İskenderun Bay 2012- Dalyan, (2020); Antalya Bay 2016-Cömert, (2019))*

The bycatch rate exceeded the target catch rate in Güllük Bay (2018), Mersin-Anamur (2004), Mersin-Taşucu Bay (2004), and Antalya Bay (2018). The highest discard rate was 77% in Mersin-Taşucu Bay (Figure 1).

Target catch rates were 71%, 77%, 46%, and 38% in the Black Sea, 62%, 71%, and 49% in the Aegean Sea, and 63%, 44%, 60%, 55%, 6%, and 10% in the Mediterranean Sea. The reason why discard values were zero in the study in Sığacık Bay in the Aegean Sea (Soykan, 2011) and in the study in Trabzon in the Black Sea (Kasapoğlu et al., 2021) is that discards were defined as bycatch (Figure 1).

In the trammel nets, cuttlefish (1), bogue (1), whiting (2), red mullet (2), and shrimp (3) were recorded as target species. The highest bycatch rate was recorded in Gökova Bay in the Aegean Sea with a total of 91%, 85% bycatch, and 6% discards (Ceyhan et al., 2009). The lowest bycatch rate was recorded in Güllük Bay in the Aegean Sea with a total discard rate of 8% (Ertosluk et al., 2019) (Figure 2).

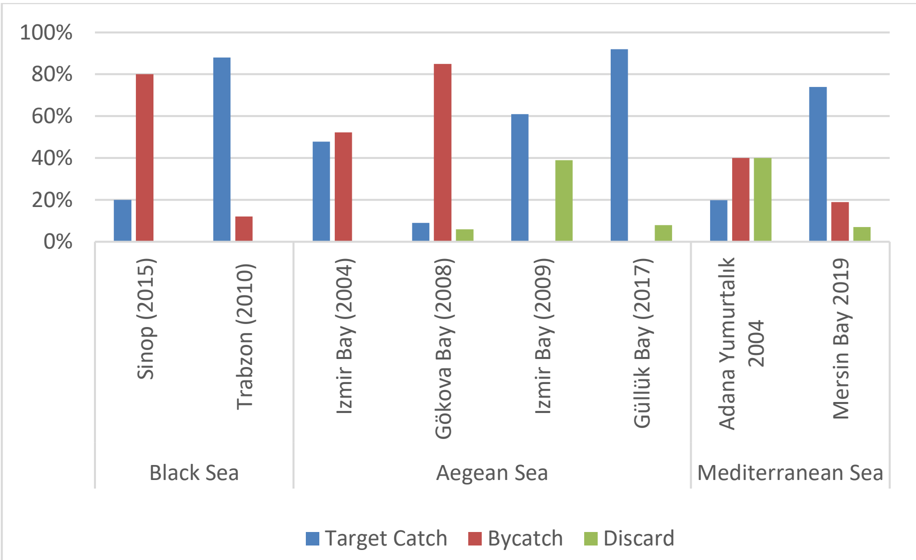

Figure 2. Target, Bycatch and Discard Rates of Gillnet/Trammel Nets Used in Turkish Coasts *(Sinop Coasts 2015- Ozdemir et al., (2017); Kasapoglu et al, (2021); Izmir Bay 2004- Akyol, (2008); Izmir Bay 2009- Aydın et al, (2010); Gökova Bay 2008- Ceyhan et al., (2009); Güllük Bay 2017- Ertosluk et al., (2019); Adana/Yumurtalık 2004- Atar and Tunçdan, (2012); Mersin Bay 2019- Bozaoğlu et al., (2022))*

In Sinop (2015), Izmir Bay (2004), Gökova Bay (2004), and Adana-Yumurtalık (2004), the sum of bycatch and discard rates exceeded the target catch rate (Akyol, 2008; Atar and Tunçdan, 2012; Ceyhan et al., 2009; Ozdemir et al., 2017). The highest discard rate was 40% on the Adana-Yumurtalık coasts in the Mediterranean Sea (Atar and Tunçdan, 2012). Target catch rates were 20% and 88% in the Black Sea, 48%, 9%, 61%, and 92% in the Aegean Sea, and 20% and 74% in the Mediterranean Sea (Figure 2).

The reason why the discard value was zero in the studies of Akyol (2008), Ksapoğlu et al. (2021), and Özdemir et al. (2017) is that the discard was defined as bycatch (Figure 2).

In the Black Sea, 97.85% target catch, 0.53% bycatch, and 1.63% discard rates were calculated with purse seine gear (Ceylan, 2011). Şahin et al. (2008) reported the rates as 91.09%, 7.89%, and 1.02% respectively. In the Aegean Sea, 74.73% target, 0.17% bycatch, and 25.11% discard rates were calculated in the Çanakkale region, and 99.65% of the discards were sprat (Ayyıldız 2006).

Yazici et al. (2006) calculated the target catch rate as 50%, the bycatch rate as 30%, and the discard rate as 20% in shrimp fishing in the Marmara Sea with the beam trawl fishing gear. Zengin and Akyol (2009) calculated the rates as 71%, 13%, and 16%, respectively. Aydın et al. (2005) calculated 22.3%, 29.5%, and 48.2% in Izmir Bay.

On the other hand, studies on longline sets are observed in the Eastern Mediterranean. Gülşahin et al. (2017) calculated the target catch rate as 75.4% and the discard rate as 24.6%. Ceyhan et al. (2014) determined the target catch (swordfish), bycatch and discard rates as 73.3%, 21% and 5.7%, respectively.

As a result of the literature review, it was determined that there were no scientific studies on the determination of target, bycatch, and discard rates in fishing with traps and midwater trawl on the coasts of Türkiye.

Discussion

As a result of this study, studies determining the target, bycatch, and discard rates by weight in the fisheries carried out off the coast of Türkiye were identified, and the rates were compared. In the studies on bottom trawling, it was observed that the bycatch rate varied between 29% and 77% in the Aegean and Mediterranean regions, and in many studies, the bycatch rate exceeded the target rate. In the Black Sea, the bycatch rate is lower than these two seas. It is thought that one of the most important factors in this difference is the species diversity in the seas. While Aksu et al. (2023) and Soyer (2018) found bycatch rates below 30% in their studies in the Black Sea, Kasapoğlu et al., (2021) and Ceylan et al. (2013) found bycatch rates of 54% and 62%, respectively. The high bycatch rates detected in the two studies (Ceylan et al., 2013; Kasapoğlu et al., 2021;) can be attributed to various factors such as the region where the study was conducted, the methodology used, the survey duration, and the depth and characteristics of the fishing equipment. Species diversity is lower in the Black Sea compared to the Mediterranean and Aegean Seas, where multi-species fishing practices contribute to high bycatch and discard rates (Soyer, 2018; WWF, 2022). Therefore, species diversity and fishing methods in the seas play a critical role in determining bycatch and discard rates. According to FAO (2023), bottom trawling is characterized by moderate discard rates (between 15 and 40 percent) in all Mediterranean sub-regions and in the Black Sea. Although all fishing gear produces discards, bottom trawling has the greatest impact (Machias et al., 2001).

The discard rates are lower in trammel nets compared to bottom trawls, with the highest discard rate reported as 40% in a study conducted off the coast of Adana-Yumurtalık. It has also been emphasized by Karakulak et al. (2012) that the discard rates of passive fishing gear are much lower than those of active fishing gear. Since gillnets are highly species and size-selective fishing gears, bycatch rates are low (Lucchetti et al., 2020; Maynou et al., 2011; Papaconstantinou et al., 2000).

As seen in the studies of Soykan (2011), Akyol (2008), Özdemir et al. (2018), and Kasapoğlu et al. (2021), it is evident that there is confusion regarding the definition and calculation of the bycatch category. This situation leads to discrepancies in processes such as the analysis and interpretation of the data collected on bycatch. Consistent with GFCM requirements, providing a minimum set of standards for the collection of discarded data and standardizing the data to be collected, including the forms to be used, is important to develop and implement an effective and harmonized discard monitoring system (FAO, 2019).

While the bycatch rate of purse seines is below 10% on the Black Sea coast, it increases to 25.7% on the Aegean Sea (Çanakkale coast) (Ayyıldız, 2006; Ceylan 2011; Şahin et al., 2008). The higher bycatch rate in the Aegean Sea is attributed to discarded sprat resembling the radar image of the target catch of sardines (Ayyıldız, 2006). Studies indicate that purse seine fishing is highly efficient and target-oriented, with high rates of target catch and low discard rates. Consistent with these findings, purse seine fishing, which constitutes a significant portion of the total catch in the GFCM (General Fisheries Commission for the Mediterranean) Region's Mediterranean and Black Sea sub-regions, generally exhibits low discard rates (typically well below 15 percent) (FAO, 2023). These data suggest that bycatch and discard rates in purse seine fisheries may be at a tolerable level.

The capture rates of bycatch species by beam trawls are significant. The number of studies should be increased to better understand the pressure of this prey species on surrounding species.

In studies conducted in the Eastern Mediterranean using longlines, bycatch rates were found to be around 25% (Ceyhan et al., 2014; Gülşahin et al., 2017). According to FAO (2023) data, these rates are classified as medium discard. Therefore, more studies are necessary to achieve lower discard rates in longline fishery.

The increase of invasive species in ecosystems leads to a significant rise in bycatch, particularly in small-scale fisheries. These species disrupt local fish populations and upset the natural balance of marine ecosystems, hindering fishers' ability to catch target species. Small-scale fishers often catch fewer target species, with the majority of their catch consisting of invasive species that hold little to no economic value. This situation not only threatens fishery sustainability but also results in economic losses and jeopardizes the livelihoods of local fishing communities (Bozaoğlu, 2012; Çınar et al., 2021; Öndes et al., 2023; WWF, 2023). For small-scale fisheries, both target and bycatch are considered sources of livelihood and food as long as they have commercial and food value (WWF, 2022). However, it has been reported that the amount of discarded catch is generally below 15% by weight in all GFCM (General Fisheries Commission for the Mediterranean) sub-regions for small-scale fisheries (FAO, 2018). One of the most significant issues with gillnets is the labor and effort required to remove discarded species from the net. Another concern is the incidental capture of endangered species as discards, which can adversely impact their populations (Bozaoğlu, 2012).

Although it provides 22% of the world's total catch, more than 50% of the total discards are from trawling (Graham et al., 2006). Therefore, as observed in our current study, much of the scientific research is focused on bottom trawl nets. Cömert (2019) stated in his study that studies on active fishing gears, like ours, are generally centered on bottom trawling. These studies often focus on specific fishing areas and single fishing gears, rather than providing regional estimates of bycatch or discards (Kiyağa, 2024).

Conclusions

As a result, efforts to increase the efficiency of fishing gear, such as reducing bycatch and developing more environmentally friendly gear, should be supported. According to the "Regional Action Plan for

Small-Scale Fisheries" published this year by the General Fisheries Commission for the Mediterranean (GFCM), investments are being directed towards increasing selectivity, protecting biodiversity, minimizing bycatch, reducing interactions between sensitive species and predators, and improving energy efficiency (GFCM, 2023). To achieve comprehensive fisheries management, there should be an increase in scientific studies to assess the bycatch and discard rates associated with fishing methods. Furthermore, upon reviewing studies along the Turkish coasts, the lack of research on beam trawls and traps is also noticeable. In order to solve the this problem, it is necessary to determine the status of bycatch and selectivity of all fishing gears in Türkiye.

Ethical approval

The author declares that this study complies with research and publication ethics.

Informed consent

Not available.

Conflicts of interest

There is no conflict of interests for publishing their study.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

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Ecosystem Characteristics and Trophic Model of the Artificial Reef Ecosystem in the Sea of Oman, Sultanate of Oman

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Abstract

This study aimed to understand the structure and function of the artificial reef ecosystem of the Sea of Oman and its stability and maturity. For this study, the trophic model of the Sea of Oman's artificial reef ecosystem was described using the Ecopath with Ecosim (EwE) ecosystem modeling software (Version 6.6.7). The essential characteristics of the aquatic system were identified using a total of 38 fish species/functional groups, spread across an area of 140 km2 of artificial reef farm. The mean trophic level of the artificial reef ecosystem of the Sea of Oman was 3.039. Sharks were the keystone species of the studied ecosystem. *Heniochus acuminatus* and *Chaetodon gardneri* were the species with the highest niche overlap, whereas *Acanthurus sohal* and other crustaceans, and Terapon puta and *Saurida undosquamis* were the species with the lowest niche overlap. It was found that the ratio of total primary production to total respiration of the ecosystem studied was more than one, indicating that the system produces more energy than it uses to respire, and the ecosystem of the Sea of Oman can be regarded as a developing system because of its low degree of stability and maturity. The omnivory index was 0.260, the connectance index was 0.159, the total biomass to total throughput ratio was 0.006, Finn's cycling index was 5.41, the total primary production to total biomass ratio was 64.895, and the total primary production to total respiration ratio was 4.424. The results indicate that the artificial reef ecosystem in the Sea of Oman can be categorized as immature (in the early developmental stage). Further study is needed to improve the input data and track ecosystem health, as well as exploring other management strategies. Based on the outcomes of the study, it is suggested that environmental management of the reef ecosystem, along with the fish catch data, should be taken into consideration for future research.

Keywords: Artificial reefs; Ecopath with Ecosim; trophic interaction; ecotrophic efficiency; Sultanate of Oman

In vitro toxicity of triclosan in the oyster, *Crassostrea madrasensis*

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Abstract

Triclosan (TCS) is an antimicrobial compound found in numerous consumer products and plastic leachates. Around the world, TCS is regularly released into aquatic environments due to the inadequacy of current wastewater treatment methods in eliminating it. According to short-term ecotoxicity testing, TCS is considered extremely hazardous to aquatic life. In this study, we evaluated the acute toxicity of TCS in heart and gill cell cultures derived from the Indian brackishwater oyster, *Crassostrea madrasensis*. Our experiments using XTT assay demonstrated that IC_{50} values of TCS after 24 h exposure were 3.3823 mg L^{-1} and 2.7553 mg L^{-1} in heart and gill cell cultures, respectively. On acute exposure for 120 h, the IC_{50} value dropped to 2.2541 mg L^{-1} in heart cell culture, showing a time-dependent increased toxic response to the compound. Although these concentrations of TCS are much higher than the present concentrations in the surface waters and sediments of the sea/estuary, we cannot overlook the fact that TCS exhibits high lipophilicity, accumulates in the sediment over the years, and resists degradation in anaerobic and dark environments, leading to bioaccumulation in sedentary organisms like oysters. Therefore, continued monitoring of TCS levels in the marine environment with particular emphasis on sediment concentration and bioaccumulation level, and assessments of lethal and sublethal effects on sedentary organisms are needed.

Keywords: triclosan (TCS), cell culture, toxicity, bivalve, *Crassostrea madrasensis*, IC_{50}

A Studies on Morphometric and Meristic Biology of Asian Stinging Cat Fish *Heteropneustes fossilis* (Bloch, 1794): A Key for Identification

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Abstract

Heteropneustes fossilis commonly known as Singhi, occurs in freshwater bodies like pools, tanks, lakes, stream and rivers of india. Its is an air-breathing fish containing pharyngeal lungs as accessory respiratory organs which enables it to tolerate low oxygenated and eutrophicated water bodies like Sarua lake Campiorganj, Gorakhpur, U.P. There is no detailed study was made on morphometric biology of this species directly from particular waterbody. In the present study revealed morphometric characterstics of *H. fossilis* by using multi-linear dimensions from Sarua lake Campiorganj, Gorakhpur, U.P.. A total 48 individuals of *H. fossilis* were collected with the help of local fisherman by using cast nest, gill net and conical trap between October 2023 to February 2024. For each individual, total numbers of fin rays were counted with the help of magnifying glass. The body weight were measured by using digital balance and various lengths were taken by using slide calipers to the nearest 0.01 gm and 0.01 cm accuracy respectively. The body weight were ranged between 2.45 to 112.32 gm, and total length ranged from 5.34 to 28.68 cm. The fin formula of *H. fossilis* is: dorsal, D.6; pectoral, Pc,1/6-7; pelvic, Pv. 6; anal, A.63-71; and caudal, C. 14-17. The findings of the current study can be very effective for identification and stock management of this particular species in the Sarua lake, Campiorganj, Gorakhpur, U.P., India.

Keywords: Morphometric, Meristic Biology, Asian Stinging Cat Fish, *Heteropneustes fossilis*

Radiological Assessment on Consumption of Fish from Kinik Stream Near Contaminated Fly Ash Dump Site of Seyitömer Thermal Power

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Abstract

The constant trend of modernization continuously increases energy demand. Among the sources of energy are the coal-fired thermal power plants. Türkiye has large coal reserves, and its government has encouraged its exploitation to reduce coal imports from abroad. Among the 55 thermal power plants operating in Türkiye is Seyitömer thermal power plant, which has an installed power of 600 MW. It is located at Seyitömer in Kütahya province. Fly ash is the waste material from the energy production of thermal power plant and contains radioactive materials. The dump site of fly ash from Seyitömer thermal power plant is located about 3 km northeast of the power plant. It spreads over agricultural fields along the Kinik Valley and was also introduced into Kinik Stream, which is used for irrigation purposes in the Seyitömer region. In this study, the activity concentration of radionuclides from fly ash samples of Seyitömer thermal power plant has been measured. RESRAD ONSITE Code 7.2 has been used to simulate radiation dose and cancer risk due to the radionuclides in the samples in 100 years. Results revealed that the maximum dose is 1.95 mSv/y at 100th year wherein the component due to the consumption of fish from Kinik Stream is 0.13 mSv/yr. The cancer risk reached a maximum value of 3.20×10^{-3} at 100th year wherein the component due to the consumption of fish was 4.55×10^{-4}.

Keywords: Fly ash, thermal power plant, radiation dose, activity concentration, RESRAD code, cancer risk

Improving the antioxidant defense system of common carp (*Cyprinus carpio*) exposed to Zinc-Oxide nanoparticle with probiotic Lactobacillus

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Abstract

Because of features of nano technology and insufficient side-effects of these particles, and suitable effects of probiotics on aquatic animals on the other hands, in this study the effects of nano zinc were examined on common carp with dietary supplement of prebiotic lactobacillus. After 42-day feeding with probiotic, fish were exposed in six treatments, and after 42 day dietary supplement with probiotic, according to the OECD standard method, fish exposed to acute and sub-acute nano zinc for 4 and 10 days respectively. At the end of sub lethal toxicity test, fish samples of serum and liver tissue were extracted and biochemical markers of liver enzymes were examined. Nano-zinc alone had damaging increased effect on AST and malondialdehyde enzymes with reduction damage on glutathione reductase, whereas probiotics alone acted contrary to the effects of nano-zinc. The combined use of nano-zinc and probiotic could reduce the damaging effects of nano-zinc on glutathione reductase and malondialdehyde enzymes, but AST was also increased. Glutathione S-transferase as well as ALT had no significant effect on this treatment. There was no significant effect on biochemical markers of probiotics alone, but nano-zinc had damaging decrease effect in glucose, direct bilirubin, total bilirubin, but also increase effect on protein. The combined use of probiotics and zinc increases in glucose, bilirubin, total and direct bilirubin as well as a decrease in protein. Using a combination of probiotics and nano-zinc stimulate non-specific immune in common carp and has been able to improve liver indices.

Keywords: Probiotic, Nano zinc, Histopathology, Clinical enzyme, Anti-oxidant defense

Length-weight Relationship of spotted sardinella (*Amblygaster sirm*) from Fish market of Población, Bongao, Tawi-Tawi, Philippines

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Abstract

Amblygaster sirm, locally known as "*Kasig*," is a small pelagic fish abundantly caught along the coastal areas of Tawi-tawi, Philippines, during its season. Despite its humble cost, its abundance renders it commercially significant, crucial for supporting food security amidst the region's growing population. Understanding the correlation between length and weight is imperative for assessing the size and abundance of this species in the wild. In this study, samples were collected from the wet market of Poblacion, Bongao, Tawi-Tawi, Philippines. Total length was measured using a 100 cm ruler, while total weight was recorded with a digital weighting scale accurate to 0.01 g. The observed length ranged from 11 cm to 16.5 cm, with the highest frequency occurring between 11 cm and 12.5 cm. Statistical analysis revealed a mean length of 12.37 cm and a corresponding variance of 0.14 cm. *Amblygaster sirm* exhibits a proportional growth pattern concerning its length and weight, with an exponent close to 3 suggesting a proportionate shape. The exponent b, determined as 2.133001, indicates isometric growth which means that as the fish grows longer, its weight increases at a consistent rate and the fish remains relatively constant as it grows, maintaining a consistent proportionality between its length and weight. These findings shed light on the weight-length relationship within the weight range of 12 g to 15 g and the length range of 15 cm to 20 cm, providing valuable insights into the dynamics of this economically important fish species.

Keywords: *Amblygaster sirm,* Tawi-Tawi, Length-weight relationship, Wet market, Isometric

Present Status of Fish Harvesting, Fisheries Resources and Fish Consumption in Pakistan

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Abstract

In Pakistan, fish is generally consumed during the winter season starting from October till April. The major reasons for the low consumption is due to the consumer preferences and export level. Pakistan exports fish mainly to Europe, US, Japan and Middle Eastern countries, accounting for only 0.25 per cent of world exports. From the existing natural resources, the total export potential has been estimated to be about US $1 billion. The main sources of fish supply are from Mangla, Tarbela and Shahpur dams, Chashma barrage, River Ravi, Sutluj, Indus and privately owned fish farms. The share of fish protein as a proportion of total expenditure on animal protein is higher for lower income groups, and poor people consume mostly low-priced fish. This shows the importance of low-priced fish as a primary source of protein among poor households in developing countries, although in many cases this low-cost fish is derived from inland capture fisheries. The main problems faced by the fishing industry in Pakistan are technical, operational and regulatory in nature. Most of the institution are working for the uplift of the fishing industry through a number of measures. It carried out a sector study identifying the key issues being faced by the industry, and later worked closely with Karachi Fish Harbour Authority (KFHA) and Fishermen Cooperative Society (FCS) in the clean-up and improving hygienic conditions of the fish harbour, encouraging fishermen to use modern on-boat storage and handling techniques, boat modification, training of fishermen, etc. By adopting modern techniques of fishing and fish processing, Pakistan can exploit the huge opportunity that exists in the fisheries sector. On the coast of Pakistan, there are more than 30 species of shrimps, 10 species of crabs, five species of lobster and about 70 commercial species of fish including Sardine, Hilsa, Shark, Mackerel, Butterfish, Pomfret, Sole, Tuna, Sea Bream, Jew Fish, Cat Fish and Eel.

Keywords: Fish consumption, resources, riverine, marine, fish species

Replacement of Fish meal with Soybean meal in the Practical Diets for Giant Murrel, *Channa marulius (*Hamilton1822): Growth, Feed Utilization and Digestibility

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Abstract

Growth and digestibility trials were conducted using gaint murrel, *Channa marulius*, to obtain apparent digestibility coefficient values for fish meal, soybean meal and corn meal; to formulate diets based on values of the protein feedstuffs; and to evaluate the effects of replacing 25%, 50% and 75% of fish meal in control diets with soybean for growth, feed utilization, efficiency and carcass composition. Supplemental methionine was added to the diet formulation in which soybean were replaced 75% of the diet. Diets were formulated and fed to *Channa marulius* fingerlings twice daily for 70 days. The protein and energy digestibility of fish meal and soybean were high (>95% and >85%, respectively; P< 0.05). At 75% fish meal replacement with soybean (without methionine supplementation), growth and feed utilization efficiency indicators were depressed compared with other diet treatments which had a similar (P>0.05) growth and feed utilization efficiency to those fed the control diet. The carcass compositions of *Channa marulius* in all diets were similar (P>0.05) and the vital organs histology of *Channa marulius* fed any of the diets showed no alterations. The results showed that 50% of fish meal protein in practical *Channa marulius* diets can be replaced with soybean and that *Channa marulius* can utilize supplemental methionine, thereby allowing up to 75% of the dietary fish meal protein to be replaced by soybean.

Keywords: *Channa marulius,* supplementation, growth, soybean meal, vital organs, fish meal

The Effects of Microplastic Exposure on the Growth Characteristics of the Green Algae *Chlorella* sp. Used in the Aquaculture Industry

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Abstract

Microalgae are used in the aquaculture industry mainly for nutritional purposes. They are produced in engineered systems called photobioreactors either on-site or purchased in concentrated form from vendors. The production facilities typically use plastic-based infrastructure, such as pipes, tanks, and bioreactors. One potential risk of this reliance is related to plastic's physical deterioration that generates substantial amounts of micro-sized particles, called microplastics. Microplastics are known to manipulate growth characteristics and the nutritional value of the algal biomass. Therefore, it is critical to understand the influence microplastics have on species used in the aquaculture industry. In this study, *Chlorella* sp., routinely used by a Turkish aquaculture company, was cultivated during exposure to different concentrations of micronized PVC (polyvinyl chloride), the plastic type frequently used in cultivation systems. The resultant productivity metrics, including growth rate, and photosynthetic performance metrics, such as maximum photochemical yield (Fv/Fm), relative electron transport rate (rETR), and non-photochemical quenching (NPQ), were assessed as a function of culture age. The productivity and photosystem-related physiological parameters varied with microplastic concentration and exposure time. These results can be used to assess the effects of microplastic-driven changes on the reliability of microalgae-based feeds used in the aquaculture industry.

Keywords: Microalgae, Microplastics, PVC (polyvinyl chloride), PAM (pulse-amplitude modulated) Fluorometry

Edible Marine Gastropod and Bivalve Species: Fresh and Culinary Offerings in the Local Market During Ramadan in the Southernmost Province of the Philippines

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Abstract

The southernmost region of the Philippines, encompassing provinces such as Tawi-Tawi, experiences a unique culinary transformation during the holy month of Ramadan. Amidst the observance of fasting, the local markets come alive with an abundance of edible gastropod and bivalve species, serving as integral components of the province's culinary heritage. Despite the cultural significance, there is limited research on the diversity and availability during this time. This study investigates the diversity and culinary offerings of edible gastropod and bivalve species in the local markets of Tawi-Tawi during Ramadan. Samples were surveyed from two major markets, Bongao Public Market and Batu-Batu Panglima Sugala Market, during the Ramadan period in 2023. A total of 19 species were documented, with notable mentions including *Hippopus hippopus*, *Tridacna maxima* and *Tridacna squamosa* which are listed under the Convention on International Trade in Endangered Species (CITES), as well as the locally threatened gastropod *Tectus niloticus*. Prices of fresh products roughly ranged from 0.36 USD to 2.70 USD, depending on size, species, and whether they were heaped or piled. Notably, culinary practices were observed whereby unsold products were either boiled or pickled in vinegar for resale the following day, or some were used as viand, showcasing the resourcefulness of local vendors. This study contributes valuable insights into the diversity and culinary utilization of gastropod and bivalve species during Ramadan in the southernmost province of the Philippines, addressing important gaps in the understanding of diversity of marine species, the local food systems and cultural practices.

Keywords: Gastropod, Bivalves, Market survey, Marine products, Culinary

Multistrain probiotics enhance the growth performance, survival and improve the health status of *Labeo rohita*

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Abstract

The study aimed to check the effect of probiotic supplementation mixture of *Saccharomyces cerevisiae, Bacillus subtilis, Bacillus licheniformis, Trichoderma long brachium* (Digest 54 plus) on growth, hematological and immunological parameters of *Labeo rohita* fingerlings. A total of 240 fish samples were divided into four experimental groups: Group A served as the control (no probiotics + 30 Cp feed), Group B received probiotics mixture at 0.25g/kg + 30 CP feed, Group C received probiotics mixture at 0.50g/kg + 30 CP feed, and Group D received probiotics mixture at 0.75g/kg + 30 CP feed. Each experimental group was divided into triplicates containing 20 fishes in separate tanks. After 60 days, a significant increase in fish growth and improvements in feed conversion ratio (FCR) and protein efficiency ratio (PER) were observed in Group D. Hematological parameters including hematocrit (Ht), hemoglobin (Hb), red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were assessed. The results showed that the RBC count was significantly highest in Group D (3.47 cells×106 mm-3, P <0.05). Moreover, the highest hemoglobin level was recorded in Group D (90.1 ± 0.05 g/dL, P <0.05) after 60 days, whereas the lowest was in the control group (74.4 ± 0.04 g/dl). Group D also exhibited the highest MCHC (32.44 ± 0.06 g/dL, P <0.05) which was significantly higher compared to the control group (29.89 ± 0.05g/dL) throughout the 60 days. Additionally, the total leukocyte count in Group D was substantially higher (P <0.05) than the control group. In conclusion, treatment D significantly influenced survival, with a rate of 91%. Based on the findings of this study, incorporating probiotics into fish feed formulations could be beneficial for aquaculture practices aimed at optimizing fish health, growth, and overall productivity.

Keywords: Multistrain probiotics, *Labeo rohita,* feed efficiency, immune response, health status

Spatial Analysis of Güllük Wetland Earthen Ponds with Digital Technology

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Abstract

Aquaculture, specifically sea fish farming, has been established in earthen ponds within the Güllük Delta (Muğla/Milas) since 1986. Currently, 60 enterprises in the region contribute to an annual production of 3 thousand tons of sea bream, sea bass, meagre, and red porgy. This study aims to elucidate the temporal and spatial analysis of earthen ponds in the area through the application of digital technology tools. Observations on temporal and spatial changes are conducted using Landsat 5 and Sentinel-2 satellite images. The utilization of Geographic Information Systems (ArcMap) facilitates the mapping process. The adoption of digital technology in this study is driven by its contemporaneity and cost-effectiveness. Satellite imagery and Geographic Information Systems are employed to meticulously document and present the temporal and spatial change in earthen ponds from 1986 to 2023. This approach provides a comprehensive understanding of the evolution of sea fish farming practices in the Güllük Delta over the specified timeframe.

Keywords: Earthen Ponds, Digital Technology, Güllük Wetland.

Evaluation of the Effects of Experimental Parameters on COD Removal from Leachate Water by Electrocoagulation Process

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Abstract

Since leachate is a complex and highly variable wastewater, it is the most difficult to treat in wastewater. Electrochemical processes are among the most preferred methods in leachate treatment. The most preferred electrode materials are aluminum and iron, as they are economical, effective and easily soluble in the electrocoagulation process. In the case of using aluminum electrodes, it produces Al3+ and Al(OH)2+ species, which are initially converted to Al(OH)3 and subsequently converted to Aln(OH)3n as a result of the electrolytic dissolution of the aluminum electrode. In this study, the effects of current density, initial pH, distance between electrodes, mixing speed and initial temperature on COD removal efficiency were investigated. Experimental studies were used in a 20cmx8cmx10cm reactor made of plexiglass. The electrodes are arranged in a monopolar parallel arrangement with three anodes and three cathodes. In the COD analysis, the standard method used is the SM 5220.D Closed Reflux Colorimetric method. In the experiments, COD removal efficiencies were determined according to current density 15-25 mA/cm2, pH 3-9.5, temperature 20-60oC, stirring speed 100-300 rpm, distance between electrodes 1-2 cm. In the light of the data obtained, the highest turbidity removal efficiency was determined as 62% at current density 20 mA/cm2, pH 5, initial temperature 20°C, distance between electrodes 1 cm, stirring speed 300 rpm. It can be said that this is due to the tendency of aluminum to hydrolyze and adsorb colloidal structures on the surface of the electrode. Thus, it can be said that the electrocoagulation process is a suitable process for turbidity removal from leachate.

Keywords: Electrocoagulation, leachate, turbidity removal, Al electrode.

1. Introduction

In recent years, the increase in population and urbanization have led to rised in solid waste production, bringing with it concerns about environmental protection and sustainability (Azni, 2009; Huda et al., 2017). Landfill leachate is a type of wastewater that has a high concentration of organics, heavy metals and other recalcitrant organic pollutants (Wang et al., 2009). Even though approaches like as reducing to amount of solid waste and preventing environmental pollution are adopted, landfill remains the presiding method of solid waste disposal in many countries. The age of the landfill has the most significant affect on leachate characteristics. The leachate can be classified into three groups based on the age of the landfill, ‘‘young”, ‘‘intermediary” and ‘‘mature” landfill leachates. The ‘‘young” leachates are generally from landfill which have <5 years old and are known for their high concentration of biodegradable organic compounds.The ‘‘mature” leachates are typically from old landfill with >10 years old. These leachates are characterized by medium concentrations of organic matter with a high percentage of recalcitrant compounds generally composed of humic substances (Dia et al., 2018; Mandal et al., 2017; Renou et al., 2008). The choice of treatment method is mostly based on the properties and compositionof the leachate. Various treatment methods such as aerobic and anaerobic processes, flotation, coagulation-flocculation, chemical precipitation, adsorption, and air stripping have been used for leachate treatment (Huda et al., 2017; Dia et al., 2018). Aerobic and anaerobic biodegradation processes are easy to use, low treatment costs, and are effective in removing biodegradable organic substances and nitrogen (Kurniawan et al., 2006).

However, despite the economic benefits and ease of application of the method, they can cause serious environmental problems in the treatment of young leachates.

As a result, alternative technologies such as secondary and tertiary treatment processes (electrocoagulation, adsorption, UV, O3, Fenton's reagent, advanced oxidation processes) are needed in the treatment of leachate coming from landfills.

Among these treatments electrochemical water and wastewater treatment methods such as electrocoagulation (EC) , electrochemical oxidation (EO), anodic oxidation (AO), electro-fenton process (EF), peroxi-coagulation process, etc. receive have great attention due to its simplicity, efficiency, lower operating cost estimated to other treatment processes (Kumar et al., 2015.). In EC, differences in electric potentials are used to generate coagulants which can remove COD, nitrogen, phosphorus, turbidity, and color removals in wastewater (Dima et al., 2005; Irdemez et al., 2006). The basic reactions that occurs in an EC cell are described in equations (1)-(3).

At the anode: $M_{(s)} \rightarrow M_{(aq)}^{n+} + ne^-$ (1)

At the cathode: $2H_2O + 2e^- \rightarrow 2OH^- + H_2$ (2)

In the bulk solution: $M_{(aq)}^{n+} + nOH^{-} \rightarrow M(OH)_{n(s)}$ (3)

Where $M_{(s)}$= metal, $M_{(aq)}^{n+}$= metallic ion (aluminum ion), $M(OH)_{n(s)}$= metallic hydroxide, and ne^{-}=the number of electrons transferred in the reaction at the electrode. It should be noted that equation (3) describes a simple case of metallic hydroxide formation. In fact, depending on the pH level and the relevant metal, a wide range of complex metallic species can form (Dia et al., 2016). When Al electrode is used upon electrolytic dissolution, it produces cationic species such as Al3+, Al(OH)2+, Al(OH)3 and polymeric forms Aln(OH)3n.

The aim of this study is to investigate the effects of process parameters in terms of COD removal in the treatment of landfill leachate with the EC process using aluminum electrodes. For this purpose, process parameters such as process performance, initial pH, electrolyte concentration and inter-electrode distance were examined and optimized.

2. Material and methods

2.1. The raw landfill leachate

The landfill leachate used in this study was sampled from a municipal landfill located in the province of Bingol, Turkey. The leachate was collected (without any filtration) in plastic containers and kept in the laboratory at 4°C before experiments. Characteristics of leachate were given in Table1 and then analyzed as per standard methods (APHA, 2005).

Table 1. Characteristics of landfill leachate

Parameter	Unit	Value
pH		8.35
Conductivity	mS/cm	47
Total solids	mg/L	7700
Total volatile solids	mg/L	2871
Suspended solids	mg/L	221
Volatile suspended solids	mg/L	35
TDS	mg/L	6654
COD	mg/L	4175
BOD_5	mg/L	1650
chloride	mg/L	2872
BOD_5/COD	mg/L	0.4
NH_3-N	mg/L	2438.7
Turbidity	NTU	228

2.2. Electrocoagulation system setup

The basic EC setup used in this work is presented in Fig. 1

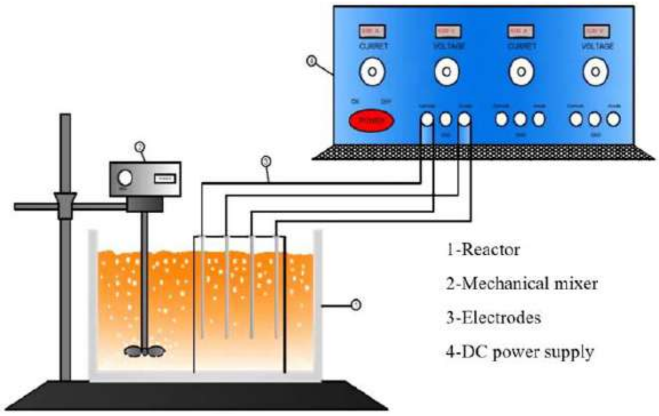

Figure 1. Electrocoagulation process

Aluminum electrodes with an effective surface area of 25 cm2 were immersed in the 500 m reactor. In this study, 1/4 diluted leachate was used. A reactor made of plexiglass with dimensions of 20cm x 8cm x 10cm was used in the processes. It consists of aluminum metal sheets as anode and while the cathode was in stainless steel. The electrodes are arranged in a monopolar parallel arrangement with three anodes and three cathodes. To ensure complete mixing, it was mixed throughout the experiment period by a Daihan brand HS-30D model mechanical stirrer immersed into the reactor from the top. In experiments, current density was 15 - 25 mA/cm2, pH 5 - 9.5, temperature 20 - 60oC, stirring speed 100 - 300 rpm, distance between electrodes 1 - 2 cm removal of COD yield values at the end of sampling intervals of 1, 3, 5, 10, 15, 20, 25, 30, 35 and 40 minutes.

2.3. Calculation

The normalized COD concentration is defined as the ratio of COD concentration at time t (C, mg/L) to the COD concentration of influent (C0, mg/L). The removal efficiency (RE) of COD is defined as:

$$RE = (C\_0-C)/C\_0 \quad x\ 100\% \qquad (4)$$

3. Results

3.1. Performance of the EC in COD removal

3.1.1. Influence of current density

Current intensity is the most important parameter of EC process. This parameters define the amount of coagulant (Al3+) introduced in the reactor. In order to determine the best conditions for COD removal in terms of current density, different values of these parameters were applied on the raw landfill leachate. The obtained results are presented in Fig. 2.

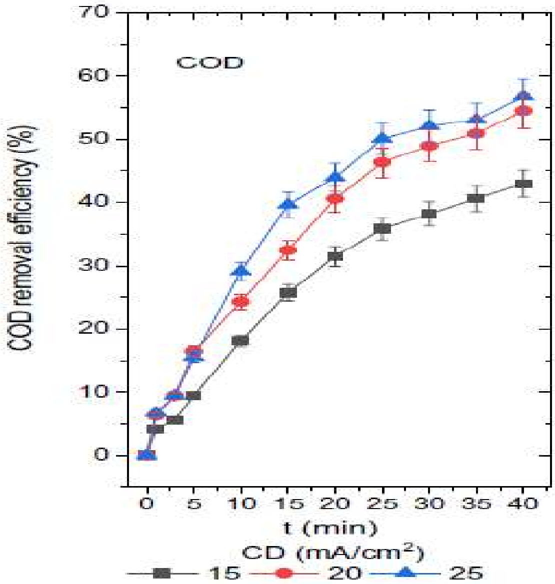

Figure 2. Variations in COD concentration and removal efficiencies of leachate at different current density values in the electrocoagulation process.

From this figure, it can be seen that, for the low current densities (15 – 25 mA/cm2), the COD elimination increased when the current density increased. Results showed that current density at 25 mA/cm2, up to 57% COD removal efficiency was achieved.

3.1.2. Influence of initial pH

pH plays a very important role in determining treatment efficiency. Therefore, experiments were designed to determine the optimum pH of leachate that allowed for maximum COD reduction. The effect of pH on the treatment efficiency was examined by altering the initial pH from 5 to 9,5 and keeping all other parameters (current density = 25 mA/cm2, reaction time = 40 min., temperature = 20°C, stirring speed = 200 rpm, distance between electrodes = 1 cm) constant. The COD removal efficiency increased by decreasing the pH to 5 and then decreased by increasing the pH to 9,5. Results showed that at pH 5, up to 87% COD removal efficiency was achieved in Fig. 3.

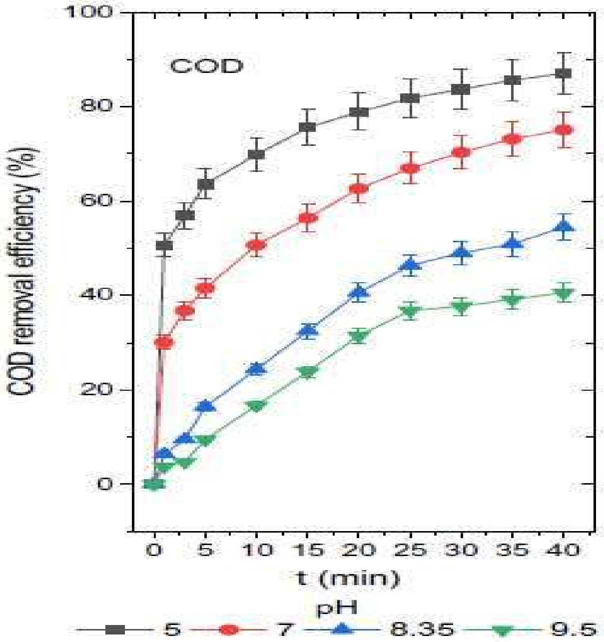

Figure 3. Variations in COD concentration and removal efficiencies of leachate at different pH values in the electrocoagulation process.

From this figure, in acidic pH, cationic monomeric species Al3+ and Al(OH)2+ prevail. When pH is between 4 and 9, various monomeric species such as Al(OH)2+, Al(OH)22+, and polymeric species such as Al6(OH)153+, Al7(OH)174+,Al13(OH)345+ transform into insoluble amorphous Al(OH)3(s) flocs through complex polymerization and/or precipitation mechanism. When pH is higher than 8, the monomeric Al(OH)4− concentration increases, decreasing the significance of insoluble amorphous Al(OH)3(s) flocs (Verma, 2017).

3.1.3. Influence of initial temperature

Based on the necessity of the obtaining of this fundamental information related to the high-temperature application of the electrocoagulation, this study was carried out to determine the effect of the the varying suspension temperatures between 20 - 60 °C on the electrocoagulation performance of COD removal. Results showed that at 50 °C, up to 60 % COD removal efficiency was achieved in Fig. 4.

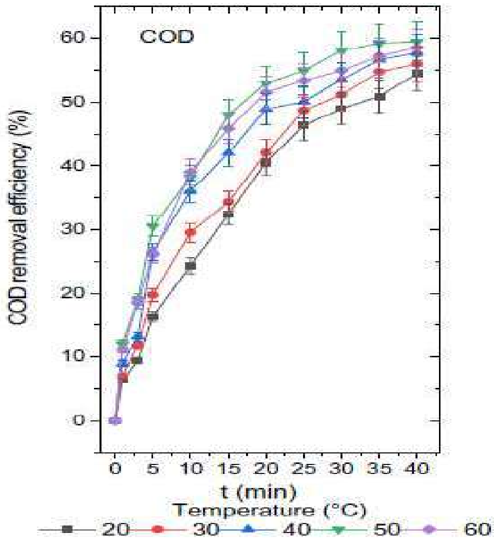

Figure 4. Variations in COD concentration and removal efficiencies of leachate at different temperature values in the electrocoagulation process.

From this figure, it can be seen that, with increasing temperature, COD removal efficiency from leachate wastewater increased (Chen, 2004). Increasing the solution temperature accelerates and increases the dissolution of Al3+ ions dissolved in the aluminum anode, and the resulting Al3+ hydrolyzes into monopolymers and Al(OH)3 solid (Al-Raad et al., 2020).

3.1.4. Influence of inter-electrode distance

Inter-electrode distance is an important variable with regards to operational costs. The effect of the distance between electrodes on COD removal from leachate with Al electrode is shown in Figure 5.

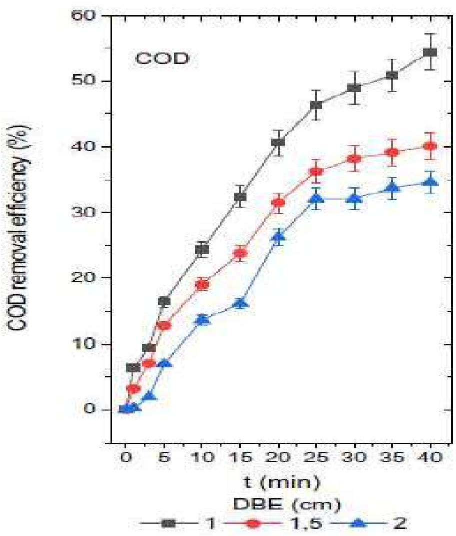

Figure 5. Variations in COD concentration and removal efficiencies of leachate at different inter-electrode distance values in the electrocoagulation process.

Fig. 5 depicts that COD removal efficiency is improved by decreasing the distance between the anodes and cathode (i.e., increasing the distance between two anodes). This can be attributed to the increase of electrical current associated with reducing the inter-electrode distance resulting in higher collisions of the ions that enhance the coagulation. Maximum COD reduction efficiency of 55% was attained with a distance of 1 cm between the two anodes.

4. Discussion

Landfill leachate comprises a mixture of diverse toxic compounds that are challenging to treat using conventional methods. This paper explores the application of electrocoagulation (EC) for leachate treatment, which leverages both sedimentation (induced by anode-released coagulants) and flotation (facilitated by cathode-generated hydrogen bubbles). The impacts of initial pH (5.0−9.5), electric current intensity (15−25 mA/cm2), initial temperature (20−60◦C), and Inter-electrode distance (1−2 cm) were investigated on COD removal. The best performance was obtained at a pH of 5, current intensity of 25 mA/cm2, and reaction time of 40 min with an initial temperature of 20◦C, leading to COD removal of 87%. This also provides an opportunity to further expand research into the use of aluminum electrodes for treating leachate. The findings of this study affirm that aluminum can serve as an electrode in electrocoagulation (EC) for treating leachate, resulting in enhanced water quality.

5. Conclusions

Electrocoagulation is a highly effective method for eliminating color and organic pollutants from wastewater. The electrocoagulation treatment of leachate was influenced by factors such as current density, initial pH, initial temperature, and initial inter-electrode distance. Our experimental results demonstrated that the highest COD removal of 87% was achieved at a current density of 25 mA/cm², a pH of approximately 5, an initial temperature of 20°C, and an inter-electrode distance of 1 cm. Meanwhile, the results indicated that electrocoagulation effectively and rapidly removed leachate.

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Ethical approval

The authors declare that this study complies with research and publications ethics.

Data availability statement

The data in this study were taken from the doctoral thesis titled “**Investigation of Treatability of Bingol Landfill Leachate Using Different Treatment Methods, and Kinetic Studies**”

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Ulva sp. as Potential Bio-adsorbent for Bromophenol Blue Dye (BPB)

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Abstract

This study focuses more on the purification of water, and the use of *Ulva* sp. as bio-adsorbent can contribute to sustainable aquaculture practices, improving water quality. Additionally, utilizing natural, renewable resources aligns with goals of promoting eco-friendly and cost-effective solutions in the aquaculture industry in Taw-Tawi. This study investigates the potential of *Ulva* sp., a commonly found green macroalgae, as a bio-adsorbent for the removal of bromophenol blue (BPB) dye from aqueous solutions. This aims to address the pressing need for sustainable and eco-friendly alternatives to conventional dye removal methods. The *Ulva* sp. biomass was collected and dried under 60°C for 24 hours. Batch adsorption experiments were conducted to evaluate the adsorption capacity of *Ulva* sp. biomass for BPB dye under varying conditions of initial dye concentration, contact time, solid-liquid ratio, and temperature. The results reveal that *Ulva* sp. biomass exhibits significant adsorption capacity for BPB dye, with maximum adsorption achieved under 30-60 mins contact time, at room temperature, and with 5-50mg of solid-liquid ratio. The adsorption kinetics and equilibrium data were analyzed using various models to elucidate the underlying mechanisms of dye uptake. Additionally, the potential regeneration and reusability of *Ulva* sp. biomass as a bio-adsorbent were explored to assess its practical applicability. Overall, this study demonstrates the promising efficacy of *Ulva* sp. as a cost-effective and environmentally benign bio-adsorbent for the removal of BPB dye, suggesting its potential application in wastewater treatment and environmental remediation efforts.

Keywords: *Ulva* sp., bromophenol blue, adsorption, bio-adsorbent, wastewater treatment.

Effects of Different Concentrations of Inorganic Fertilizer on the Growth, Carrageenan Yield and Gel Strength of *Kappaphycus alvarezii*

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Abstract

Kappaphycus alvarezii is the most farmed species of red seaweed in Tawi-Tawi because of its carrageenan. The demand for carrageenan is still high due to its wide range of uses including food, cosmetics, pharmaceuticals, printing, and textiles. Seaweed farmer diligently enriched their seaweed with inorganic fertilizer for faster production and increased income. Hence, this study was conducted at Bongao Channel at the front of the College of Fisheries Pier, Bongao, Tawi-Tawi, Philippines (5°02'07.8''N 119°44'36.6''E) for 45 days of culture to determine the effects of different concentrations of ammonium phosphate fertilizer on the growth, carrageenan yield and gel strength of *Kappaphycus alvarezii*. The study has three treatments, namely; Treatment 1 (T1) - 0g L-1, Treatment 2 (T2) - 5g L-1, and Treatment 3 (T3) – 10g L-1 of ammonium phosphate solution with 10 replicates using Randomized Complete Block Design (RCBD). Seaweed was short-immersed in fertilizer solutions for thirty (30) seconds, then placed inside of the 60 L capacity plastic tubs and partly covered overnight before planting in the site. The results showed that 10g L-1 was significantly higher ($P<0.01$) in specific growth rate (SGR) 3.02±0.79 % day-1 than the control and 5g L-1. Seaweed enriched with fertilizer decreases the carrageenan yield and gel strength of carrageenan. Therefore *K. alvarezii* enriched in high concentration (10g L-1) of ammonium phosphate solution could provide promising results in growth rate but negatively affect the quality of carrageenan gel in terms of carrageenan yield and gel strength. Enriching 10g L-1 ammonium phosphate to the seaweeds could be beneficial for the seaweed farmers but not for the carrageenan industry.

Keywords: Ammonium phosphate, *K. alvarezii*, carrageenan yield, gel strength, growth

Bioaccumulation and Impacts of Microplastics on Aquatic Plants

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Abstract

Aquatic environments are faced with microplastic (MP) and therefore nanoplastic (NPs) pollution as a result of the breakdown of plastic waste. In recent years, MP research has attracted increasing attention because MP and NPs have been reported in almost all parts of the world, even copper, air, such as the Arctic. Aquaculture products have activities in a wide variety of ecological roles depending on the characteristics of their ecosystems, characteristics and transportability. MPs are very easily converted into plant tissues, adsorbed and stored by plants. In this original, aquatic processes of MPs are carried out, the possible ecological consequences that can be realized later are summarized. Most likely, electrostatic forces, leaf morphology, and peripheral presence can be among the most important reasons that enable the adsorption and detachment of MPs. MPs adsorbed in plant tissues are easily taken up by aquatic plants. They examined MPs in the foliage, branches and stems of previous healthy plant species (*Chaetoceros neogracile, Tisochrysis lutea, Utricularia vulgaris, Lemna minor, Spirodela polyrhiza, Rhodomonas salina, Duneliall tertiolecta, Thalassiosira pseudonana, Skeletonema grethae, Phaeodactylum tricornutum*). As a result, it was determined that the growth rate of aquatic plants contaminated with MPs was not significantly inhibited and caused high eco-toxicity and oxidative damage. Therefore, MPs have a very important role in the functioning of aquatic ecosystems and their aquatic distribution in the future, and therefore in the future, MP-related aquatic states will be located in more places.

Keywords: Aquatic plants, microplastic, bioaccumulation, pollution.

Introduction

MP and NPs in aquatic habitats has repercussions on both aquatic and terrestrial ecosystems. Photosynthetic organisms, acting as primary producers, inhabit both realms. As a general trend, MPs contamination exerts toxic effects on these photosynthetic organisms. Plastic leachates, containing additives, constitute a significant source of toxicity as well. Studies have shown the accumulation of certain harmful compounds, like phthalate esters, in plants, posing risks to consumers. The adsorption of plastic particles has been evidenced across various photosynthetic organisms, while uptake and translocation in terrestrial plants have been demonstrated for NPs, raising concerns about trophic chain contamination (Larue et al., 2021).

Over the past decade, there has been a surge in research interest in MPs due to their widespread presence, even in remote areas such as the North Pole, as reported by Kanhai et al. (2018) and Hartmann et al. (2019). These small plastic particles (<1 mm) originate from various sources, including primary production within this size range and the fragmentation of larger plastic pieces, known as secondary MPs. Secondary MPs mainly consist of synthetic clothing fibers released during laundry, particles from plastic coatings abrasion, and tire wear. The accumulation of these particles over time contributes to pervasive MP pollution (SAPEA, 2019). Due to their long lifespans, widespread distribution, and small size, MPs interact with and impact various organisms. Consequently, researchers have increasingly investigated their effects on marine and freshwater organisms, demonstrating ingestion by a range of species, affecting feeding rates, oxygen consumption, growth, development, behavior, and even causing mortality. Moreover, MPs can transfer between trophic levels. Despite the extensive research on MPs effects on animals, studies on their interaction with aquatic plants are limited. Aquatic plants play a crucial role as primary producers in aquatic ecosystems, providing food and nesting habitats for many species, and are therefore equally important as animals in the environment (Van Hoeck et al., 2015).

Recent studies suggest that while MPs have minimal direct effects on plants, they exhibit strong attraction to plant tissues, leading to their adsorption and accumulation. Several mechanisms facilitate this process, including electrostatic forces, leaf morphology, and the presence of periphyton. MPs adsorbed in plant tissues can be readily taken up by herbivores, suggesting that plants may serve as a pathway for MPs to enter aquatic food webs. However, these strong interactions between microplastics and plants can also be harnessed for phytostabilization and eventual removal from the environment. Therefore, aquatic plants play a significant role in shaping the behavior and fate of MPs in aquatic ecosystems and should be considered in future research on microplastics. The goal of present study is to provide a comprehensive overview of the interactions between MPs and aquatic plants, as well as to highlight their potential ecological implications.

MPs and their introduction to aquatic environments

Plastics, synthetic organic polymers, boast several advantageous characteristics including lightweight structure, versatility, durability, long lifespan, hygiene, suitability for food, and washability. These qualities have led to their widespread use across various sectors, with plastic production witnessing a significant surge over the years. From 15 million tons in 1964, global plastic production soared to over 368 million tons in 2019, with major contributions from China and Europe alone, and is projected to double by 2040. Plastics have become indispensable in agriculture, industry, and daily life products, a trend that continues unabated. However, alongside their benefits, the rampant release of plastics into the environment has sparked considerable global concern, ranking as the second most troubling environmental issue after global warming. Unregulated discharges and inadequate waste management practices result in the widespread distribution of plastics across various environmental matrices, where they accumulate and degrade over extended periods. Moreover, weather-exposed plastic waste breaks down into smaller particles that infiltrate aquatic and terrestrial ecosystems, posing risks of absorption, ingestion, and accumulation by organisms. Plastics are categorized based on their size into macroplastics (>25 mm), mesoplastics (5–25 mm), MPs (0.1–5 mm), and NPs (<100 nm) (Azeem et al., 2021).

In aquatic environments, MPs primarily originate from various sources such as direct discharges from wastewater treatment plants, industrial and agricultural wastewater, as well as the spontaneous degradation of larger plastic debris, including macro and mesoplastics, in water (Ma et al., 2019).

The term " MPs" was initially introduced by Thompson in 2004 (Thompson et al., 2004), sparking increased attention towards the distribution and ecological ramifications of minute plastic particles in marine settings. MPs are characterized as plastic fragments with a diameter of less than 5 mm (Arthur et al., 2009). Larger plastic items degrade into smaller particles, forming what are termed secondary MPs (Andrady, 2011; Prata et al., 2020). MPs become entrapped in sewage sludge and are conveyed to natural environments through wastewater or sludge transport during various wastewater treatment processes. Despite modern wastewater treatment methods being effective at removing MPs, the annual influx of MPs into natural waters remains substantial (Hamidian et al., 2021; Wang et al., 2020). Recently, studies have indicated that the abundance of MPs at STP inlets ranges from 1 to 7000 items L^{-1} in wastewater, subsequently decreasing to 0.0009 to 81 items L^{-1} (Okoffo et al., 2019).

Plastic product production in China surged to 8.3 million tons in 2019, while global plastic product production reached 359 million tons in 2018, as documented by Plastics Europe (Shiu et al., 2020). Annually, between 4.8 to 12.7 million tons of plastic are discharged into aquatic environments. Due to mechanical abrasion and environmental degradation processes such as UV exposure, heat, and chemical reactions, large plastic items fragment into smaller particles. Among these fragments, MPs and NPs are likely the most prevalent types of plastic pollutants in the environment. The widespread presence of MPs as environmental contaminants is increasingly raising concerns (Cole et al., 2011).

MPs are pervasive pollutants present in both aquatic and terrestrial ecosystems, posing significant harm to organisms. Of particular concern is their impact on soil, where they can interfere with the growth and development of plants, potentially endangering human health. Sludge composts act as a vehicle for MPs to enter the soil, thereby influencing their distribution through soil organisms. Furthermore, MPs can modify soil structure and properties, affecting plant performance. Changes in soil physicochemical properties induced by MPs can negatively impact root characteristics, growth, and nutrient uptake in plants (Zhang et al., 2020).

When MPs are introduced into the environment, they engage in interactions with organisms across various trophic levels in aquatic ecosystems, including plants. However, the limited understanding of these interactions poses challenges for the development of phytoremediation strategies, which are essential for MPs removal. MPs can exhibit various behaviors in aquatic environments, including suspension in the water column, floating to the surface, or sinking to the bottom. This diversity in behavior contributes to the widespread distribution of microplastics throughout aquatic ecosystems. Organisms at different trophic levels may inadvertently ingest MPs, leading to a concerning trend of plastic bioaccumulation along the food chain. While much attention has been given to the ecological impact of plastic pollution in marine ecosystems, recent studies underscore the significant threat that plastics pose to freshwater ecosystems as well. Despite the extensive research on the effects of MPs on aquatic communities, there has been a notable lack of attention given to plants, which play crucial structural and functional roles in ecosystems. Research efforts have predominantly focused on animal organisms, leaving a gap in our understanding of how MPs affect plant communities and their associated ecosystems (Kalčíková et al., 2020). Moreover, as the primary interface between the abiotic and biotic components of ecosystems, plants play a crucial role in serving as early warning systems essential for addressing contamination and restricting bioaccumulation processes across the food chain and the environment (Ceschin et al., 2021).

Accumulation and Effects of MPs in Aquatic Plants

The Importance of Aquatic Plants in the Ecosystem

Aquatic plants play a vital role in shaping the structure and function of aquatic ecosystems, with their interactions influencing hydrological, geomorphological, and physico-chemical environments, as well as interactions with various organisms. The ongoing global demand for water resources underscores the need to understand how systems dominated by aquatic plants respond to environmental changes, including temperature increases and extreme climate events. In regions like the United Kingdom and China, energy policies and green initiatives are influencing research agendas and fostering international collaborations. In developing countries, rapid population growth and resource use intensification heighten the demand for aquatic botanists' services, particularly in mitigating ecological impacts caused by infrastructure projects like hydroelectric power plants. Despite these challenges, technological advances in survey methodologies, analytical techniques, ecological modeling, and remote sensing offer new avenues for advancing aquatic plant research, enabling better predictions of plant interactions and ecosystem dynamics.

Water plants indeed provide several advantages as study organisms compared to other aquatic biota. Their sessile nature allows for accurate mapping and long-term monitoring, providing valuable insights into ecosystem dynamics. Additionally, water plants are easily examined and cultured in laboratory settings, facilitating controlled experiments and detailed physiological studies. Moreover, they are increasingly recognized as valuable model organisms by researchers from various disciplines due to their ecological importance and relevance to ecosystem health. With the growing recognition of the critical role played by aquatic plants in aquatic ecosystems and the increasing interdisciplinary nature of research, high-impact journals are showing greater interest in publishing studies related to aquatic botany. This shift reflects the expanding scope of aquatic plant research and its relevance to broader scientific and environmental concerns. As a result, researchers studying water plants now have more opportunities to disseminate their findings and contribute to advancing scientific knowledge in the field.

Accumulation of MPs in Aquatic Plants

Despite decades of research on MPs and recent advancements in scientific knowledge, understanding various aspects of the MPs life cycle remains a formidable challenge. Interactions like the adsorption and accumulation of MPs by aquatic plants can lead to numerous ecological implications in aquatic ecosystems. MPs may induce trophic transfer to different herbivorous species and propagate throughout the food chain. Conversely, the accumulation of MPs by aquatic plants presents a potential avenue for their environmental removal. However, due to the unique nature of MPs as pollutants, such endeavors are inherently challenging. They come in diverse materials, shapes, and sizes, evolving their properties and behaviors over time, while their ecotoxicity potentials are modulated by the adsorption of other contaminants. Thus far, scientists have grappled with the uncertainties surrounding research on this complex pollution issue. Addressing such complexity necessitates interdisciplinary collaboration among scientists, framing MP pollution as a global concern encompassing all potential ecosystems and the entire spectrum of biological diversity they host, rather than just focusing on its impacts on oceans and marine life. This study presents existing research on the effects of MPs on aquatic plants to date.

While plants in aquatic environment are frequently exposed to plastic pollution, research confirming the impacts of MPs on plants in freshwater remains limited. Only a few species have been studied, including microalgae such as Scenedesmus and Chlorella, as well as flowering plants like *Lemna minor* L. Existing literature suggests that the primary phytotoxic effects of plastics include the inhibition of photosynthesis and the restriction of shoot and root growth, as observed in species like *Myriophyllum spicatum* L. These effects are attributed to MP particles adsorbed on external plant tissues, which create physical blockages to light and air, thereby impeding photosynthesis and respiration activities. However, studies indicate that plant species are typically affected only when MP concentrations exceed those naturally found in the environment. Low-density MPs, with specific densities less than 1 g/cm^3, disperse in the upper layers of slow-flowing waters, where they often encounter pleustophytes—aquatic plants directly in contact with water, with their roots and lower surfaces of vegetative stems floating on the water surface. Pleustophytes, despite their small vegetative body, can form floating plant covers, such as water lentils (Lemnaceae family), which create river extensions or smaller water basins. The certain water lentil species, like those belonging to the Lemna genus, can trap substantial amounts of floating pollutants, including MPs. However, the scarcity of studies on the interactions and effects of MPs on water lentils highlights the need for further investigation, given the significant role of water lentils in aquatic ecosystems.

Recent studies have shown that MPs can be adsorbed on the surface and accumulated by vascular plants (Table 1). Although not extensively studied, aquatic macrophytes adsorbed plastic with various mechanisms. Electrostatic forces of plant cell's cellulose components may attract MPs, and the roughness of plant surfaces facilitates adsorption by providing numerous attachment sites for plastic particles. Furthermore, the structural complexity of plant organisms' surfaces is a crucial factor in their interaction with MPs; increased complexity in algal thallus structures correlates with greater MP capture potential. Additionally, the presence of a periphyton layer, which may consist of microalgae, can elevate viscosity on plant surfaces, thereby improving MP retention. MPs have been found to significantly affect both the aboveground and underground parts of plants, reducing main shoot length and root activity, respectively.

In the presence of plastic pollution, marine phytoplankton increase the secretion of EPS, particularly protein-rich EPS. This increase in EPS production serves to enhance the aggregation and surface modification of plastic particles. The protein-rich nature of EPS promotes the binding of plastic particles together, leading to the formation of aggregates in the water column.

Tablo 1. The various toxic effects of MPs on aquatic plants (Ge ve ark., 2021).

Plants	**MP**			**Exposure duration (gün)**	**Toxic impact**	**Researcher**
	Type	**Size (µm)**	**Concentrations**			
Chaetoceros neogracile, Tisochrysis lutea	PS	2000	39,6 mg L^{-1}	35	The distribution of MPs in algal cultures varies depending on the type of algae and their physiological condition.	Long et al. (2017)
Utricularia vulgaris	PS	1,2, 5	15, 70, 140 mL^{-1}	7	Leaf growth rate and functional characteristics have been significantly inhibited, leading to high ecotoxicity and induced oxidative damage.	Yu et al. (2020)
Lemna minor	PE	4-12	0, 10, 50, 100 mg L^{-1}	7	Root growth has been significantly affected through mechanical obstruction.	Kalcikova et al. (2017)
Spirodela polyrhiza	PS	0,05, 0,5	10^2, 10^4, 10^6 particules $l·mL^{-1}$	5	It inhibits growth by adsorbing onto the roots of freshwater vascular plants.	Dovidat et al. (2019)
Chaetoceros Neogracile, Rhodomonas salina	PS	2	5500 particules mL^{-1}	0,25	As the sinking rate of diatom aggregates decreases, the sinking rate of cryptophyte aggregates increases.	Long et al. (2015)
Duneliалla tertiolecta Thalassiosira pseudonana	PS	0,05, 0,5, 6	25 and 250 mL^{-1}	3	The growth of microalgae was negatively affected, and the negative effects increased as the size decreased.	Sjollema ve ark. (2016)
Spirodela polyrhiza S.polyrhiza	PS	0,05, 0,5	10^2- 10^6 particules mL^{-1}	5	The adsorption of MPs onto multiple aquatic plants leads to the transfer of MPs to various herbivorous species in the ecosystem.	Dovidat et al. (2019)
Thalassiosira pseudonana, Skeletonema grethae, Phaeodactylum tricornutum, Dunaliella tertiolecta	PS	0,055, 1, 6	10^{-4} - 250 mg L^{-}	2	Marine phytoplankton are highly sensitive to smaller-sized plastics and actively modify their extracellular polymeric substances (EPS) chemical compositions to cope with pollution-induced stress. It has been found that the release of protein-rich EPS facilitates the aggregation and surface modification of plastic particles, thus affecting their fate and colonization.	Shiu et al. (2020)

It is well known that natural surface waters are contaminated with MPs. However, how these pollutants affect aquatic organisms is not yet fully understood. Professor Julie Peller from Valparaiso University in Indiana has researched the distribution of MPs in the Great Lakes of North America and found that synthetic microfibers are, on average, a thousand times more abundant in aquatic vegetation than in water or basin sediments. Specifically, these microfibers adhere strongly to fresh algae, enough to remain attached even when mechanically agitated. Her findings indicate a high likelihood that organisms feeding on aquatic vegetation may ingest many synthetic microfibers.

Conclusions

MPs are commonly found in aquatic environments. Despite being considered one of the most hazardous pollutants, their toxic effects on organisms, especially aquatic plants, remain uncertain. Further analysis of concentrations in ocean sediments, including the abundance of different polymers, sizes, and shapes, would be beneficial in viewing MPs as a pollutant group. Realistic studies are needed to measure trophic transfer using environmental concentrations and types of MPs, providing both prey and predator with sufficient time for feeding and digestion. Research is needed on the uptake and effects of MPs obtained through respiration. It is recommended to investigate which fraction of absorbed chemical pollutants in different organisms may be drawn from different types of MPs during their journey through digestive tracts and to learn about the presence of environmental chemicals separated from MPs in respiratory organs. Collaboration with scientists in other fields is needed to develop ways to reduce the release of MPs into the environment. Future research on the toxic effects of MPs on plants should involve the selection of diverse plant species to better understand the breadth of their responses. Additionally, investigations should expand beyond roots to explore the toxic effects on other plant parts such as leaves, branches, and stems. Understanding the mechanisms underlying how MPs affect plant growth and development is essential and should be a key focus of future studies. By addressing these research gaps, we can enhance our understanding of the impacts of MPs on plants and develop more effective strategies to mitigate their adverse effects on ecosystems.

Ethical approval

The author declares that this study complies with research and publication ethics.

Data availability statement

The authors declare that data are available from authors upon reasonable request. In case of unavailable data due to conditionals of funding organizations, etc., a clear explanation should be given.

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A Preliminary Assessment of Coastal Fisheries in Illana Bay, Philippines

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Abstract

The assessment of the condition of coastal fisheries within Illana Bay in Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), Philippines was conducted through key informants' interviews (KII) as well as focus group discussions (FGD) of all fisheries stakeholders in the coastal barangays fringing Illana Bay. Data on the number of fisherfolks, boats, gear types, species caught, catch rates, fishing efforts, location of fishing areas as well as major issues and concerns affecting local fisherfolks were collected. Results of the preliminary survey showed that there are an estimated seven thousand three hundred thirty-nine (7,339) fishermen out of thirteen thousand one hundred thirty-two (13,162) registered fisherfolks and a total of one thousand seven hundred ninety-four (1,794) bancas with 86% registered boats from the province of Maguindanao and 14% in Lanao del Sur. There were more than 10 types of fishing gears used with hook and line and gill net as the most commonly used. The target species were composed of eighty-nine (89) fish species and five (5) invertebrates out of thirty-two (32) families. Peak fishing season falls from September to December with sardines, round scads and tunas as the most commonly caught commodities. Declining fish catches were reported in most fishing areas. Occurrence of destructive or illegal fishing activities such as the use of dynamite, cyanide, and/or 3-ply fishing nets. Bad weather conditions, destruction of mangrove areas, heavy siltation, and proliferation of water hyacinth were common issues and concerns.

Keywords: Illana Bay, coastal fisheries, fisherfolk, mangroves, sustainability

Unveiling Ice-ice Disease in Eucheumatoid Seaweeds: Insights from Farmers' Experiences

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Abstract

Eucheumatoid seaweeds, including genera such as *Kappaphycus* and *Eucheuma*, are extensively farmed globally, mainly in tropical regions, owing to their carrageenan content. Ice-ice disease poses a significant challenge to their cultivation, profoundly impacting production. This study focused on the roots of this disease, exploring insights from farmers' experiences on ice-ice disease in eucheumatoid seaweeds, specifically in Sibutu, Tawi-Tawi, Philippines, through one-on-one interviews (N=96) and focus group discussions. The findings revealed that most farmers, predominantly male aged 31 – 60, with 11 – 25 years of experience, have been acquainted with ice-ice disease since childhood. They define it as an abnormality characterized by white, soft parts on seaweed thalli, with initial symptoms including pale thalli coloration and the presence of epiphytes/debris. Reported factors contributing to ice-ice disease include temperature fluctuations, salinity changes post-heavy rainfall, slow water currents, nutrient deficiencies, poor seedling quality, and inadequate management. Deepwater farms (nearshore) are particularly susceptible, especially during easterly winds when epiphytes proliferate, exacerbating ice-ice disease. The condition worsens during dry, hot seasons. *Kappaphycus striatus* is identified as more susceptible compared to *K. alvarezii* and *Eucheuma denticulatum*. Ice-ice disease significantly impacts farmers' livelihoods. Management strategies include inorganic nutrient enrichment, relocating infected seaweeds, and cultivating more resistant species. This research highlights the urgent need to tackle ice-ice disease in the cultivation of eucheumatoid seaweeds, given its profound impact on the livelihoods of farmers worldwide. Identifying contributing factors and vulnerable species offers crucial direction for implementing customized management strategies aimed at preserving the sustainability of production.

Keywords: Eucheumatoid seaweeds, Ice-ice disease, *Kappaphycus*, Farmers' insights, Philippines, Seaweed farming

Culture of Sea Lettuce (*Ulva rigida)* in wastewater of Aquaculture Facilities

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Abstract

Aquaculture is the fastest growing food industry in the world with values more than 5% per year according to FAO statistics and this trend will probably continue as capture fisheries are in global decline. Aquaculture is, however, now at a crossroad and there are many critical aspects of its sustainability that need to be addressed. The challenge faced by the aquaculture industry is how to maintain current production levels and even expand them without exceeding assimilative capacity of the ecosystem. This is where Integrated Multi-Trophic Aquaculture (IMTA) can become important to the industry. IMTA is an innovative solution being proposed for environmental sustainability, economic diversification, and social acceptability and IMTA can be applied to on-land and off-shore aquaculture systems. This practice combines the cultivation of finfish with shellfish and seaweed species for an ecologically-balanced aquaculture management approach. IMTA increases the long-term sustainability and profitability per cultivation unit as the wastes of the main cultured species are bio-mitigated through conversion into fertilizer, food, and energy for additional commercially valuable species. In this way, otherwise costly waste mitigation processes become revenue-generating cultivation components, which by their harvest export nutrients outside of the coastal ecosystem. In this study, cultivation potential of Sea Lettuce (*Ulva rigida,* C. Agardh, 1823), naturally distributed on the coast of Izmir, with the wastewater generated by Nile *Tilapia* (*Oreochromis niloticus* Linnaeus, 1758) in Aquaculture Systems was determined. During the study, removing nutrient (nitrite, nitrate, ammonium, and phosphate) capacity of *U. rigida*, daily growth rate, and biomass yield of *U. rigida* were analyzed.

Keywords: Green seaweed, *Ulva*, Tilapia, Fish effluent, bioremediation, IMTA

Introduction

Aquaculture is a sector that has developed very rapidly in recent years. Increasing aquaculture activities negatively affect the carrying capacity of water. The negative effects of aquaculture on the environment occur due to particles and dissolved nutrients resulting from fish feces and feed that cannot be consumed by fish (Krom and Neori, 1989). Fish farms have been reported to have a noticeable effect on the rapid growth of macroalgae (Rosenthal et al., 1988). For example, algae around fish farms were found to be 20 times more dense than those at control stations (Leskinen et al., 1986). The research area of macroalgae removal of dissolved nitrogen in fish ponds and fish farms has been studied by many authors (Alcantara et al., 1999; Buchmann et al., 1996; Casalduero, 2000; De Boer and Ryther, 1977; Fralick, 1979; Haglund and Pedessen, 1996). 1993; Harlym et al., 1979; Hernandez et al., 2006; Jimenez del Rio et al., 1994; Jones et al., 2001; Neori, 2004; Neori et al. 1991, 2000, 2003; Schuenhoff et al. , 2003; Shipigel et al., 1993; Troell et al., 1997; Vandermeulen and Gordin, 1990).

Vandermeulen and Gordin (1990) reported that *Ulva lactuca* grown in water coming from sea bream (*Sparus aurata*) ponds effectively removed 85% of the total ammonium nitrogen (TAN) in the water. The same researchers demonstrated that *Ulva* can be used to effectively and inexpensively remove nutrients. Neori et al. (1991) who grew *U. lactuca* in outdoor algal ponds in Israel, using water from fish ponds, drew attention to the high growth rate of *U. lactuca*, its high biomass, and decreasing C/N ratios in its composition. Shipigel et al. (1993) found that when the density of *U. lactuca* was set as 1 kg *Ulva*.m^{-2}, 90% of the amount of 2 g TAN.m^{-2}.day^{-1} in water was removed by *U. lactuca*. Jimenez del Rio et al. (1996) found that *U. rigida* as a biofilter removed 2.2 g DIN (Dissolved Inorganic Nitrogen).m^{-2}.day^{-1} in summer and 1.1 g DIN.m^{-2}.day^{-1} in winter (Jimenez del Rio et al., 1996). Neori et al. (2000) developed a 3.3 m^3 system consisting of fish, crustaceans and macroalgae and found that *U. lactuca* removed 67% of the TAN occurring in the system. Schuenhoff et al. (2003) stated that by combining the 3-stage macroalgae system with the intensive fish pond, *U. lactuca* removed 70% of the TAN in the water. Neori et al. (2003) reported in their similar study that *U. lactuca* had the capacity to remove 85-90% of TAN, thus removing 2.9 g TAN.m^{-2} per day. Msuya et al. (2006) studied the performance of *U. reticulata* as a biofilter and demonstrated the feasibility of growing algae placed in the outlet channel of fish ponds and the usability of *U. reticulata* in cleaning dirty water coming from fish ponds.

Although, integrated semi-closed or closed circuit systems, including macroalgae, were suspended for a while due to high cost investments, an exemplary semi-closed integrated system was established in Israel. In this system, the water passing from the Japanese abalone (*Haliotis* sp.) culture tanks was transferred to the pellet-fed sea bream (*Sparus aurata*) tank. The water leaving the fish tank reaches the macroalgae (*Ulva* or *Gracilaria*) tanks. The algae grown here are used to feed abalones (Neori, 2004). Abalone and sea bream grow in abundance in this system. Macroalgae is one of the extra produced products. Thanks to macroalgae, fresh seawater is added to only 20% of the water used in the system. Total nitrogen in the system is reduced by 10%.

In this study, in order to determine the potential for use as a biofilter in aquaculture systems under our country's conditions, the cultivation protocols of our nitrophilous macroalgae species (*Ulva rigida*), which are naturally distributed in our waters, and their capacity to clean fish wastewater, the nutrient (nitrite, nitrate, ammonium, and phosphate) of water samples was analyzed with algal daily specific growth rates and biomass yields.

Material and Method

Collection of Ulva Samples

Ulva species were collected from Bostanlı and İnciraltı experimental stations located in İzmir Bay (İzmir, Türkiye) (Figure 1). The coordinates of the experimental stations were measured as 38°27'22'' N and 27°05'12'' E for Bostanlı station, and 38° 24' 41.3'' N and 27° 02' 32.0'' E for İnciraltı station.

Ulva preparation

The collected *Ulva* samples were transported to Alg Culture Laboratories at Ege University, Fisheries Faculty (Bornova, İzmir) and they were washed using running water to remove dirt, moss, mud and sand. Furthermore, morpho-anatomic characters of *Ulva* species were determined. The taxonomic identification of *Ulva* species was conducted using the methodologies outlined by Taşkın (ed.) et al. (2019). The species were named following Guiry and Guiry (2024) and their identification was verified through the algaebase website.

Experimental Design

Experimental units with a water volume of 5 liters were used in the trials. The volume of the containers is set to 4 liters. Nutrient-rich wastewater taken from Nile Tilapia (*Oreochromis niloticus*) aquariums. Fish wastewater was used in *Ulva* cultivating units at a rate of 25% and 50% in the trials. The group in which only Conway medium was added to the *Ulva*s (10 $mL.L^{-1}$) was determined as the Control group. In all experimental groups, salinity was adjusted to 35‰ using reef aquarium salt. After the trial containers were prepared, *U. rigida* was placed at 2.5 g per liter.

Water Nutrient Analysis:

The determination and colorimetric calculation of the nutritional elements (Nitrate, Nitrate, Ammonium and Phosphate) found in water and causing pollution in water are explained in detail by Egemen and Sunlu (1999). According to Egemen and Sunlu (1999), before the determination process, freshly taken water samples or water samples stored in the refrigerator (≤ 4 °C) were used for the Determination of Nutrient Elements in Water.

Nitrite (NO_2) Analysis

Process:

After 46 ml of standard solutions, blank sample and samples to be analyzed are taken, 2 ml of sulfanilic acid solution was added to them, mixed and waited for 10 minutes. 1 ml of ά-Naphthylamine hydrochloride solution and 1 ml of sodium acetate solution were added, mixed, and after 10 minutes, the absorbance was determined with a spectrophotometer at 543 nm. Using the standard curve, the amount of nitrite in the environment was determined. Since the color intensity changes with salinity, the nitrate value was measured by calculating the salinity correction factor.

Nitrate (NO_3) Analysis

Process:

After 41 ml of standard solutions, blank sample and samples to be analyzed are taken, 2 ml of Phenol-Sodium Phenate Buffer and 1 ml of Hydrazine-Copper Reduction Reagent were added and mixed well, covered and stored in a dark place for 24 hours. Then, 2 ml of pure acetone was added to stop the reaction, mixed, waited for 5 minutes, 2 ml of sulphanic acid was added and mixed, waited for 10 minutes. Later, 1 ml of ά–Naphthylamine hydrochloride solution and 1 ml of sodium acetate solution were added and mixed thoroughly. After, waited for 10 minutes and detected absorbance at 543 nm. The amount of NO_3^- + NO_2^- in the water was determined by using the standard curve. The NO_3^- amount in the water was found by subtracting the previously found NO_2^- value. Since Nitrate was determined in the seawater, the corrected absorbance along with the salinity value was calculated by finding the factor as in the determination of nitrite.

Ammonium (NH_4) Analysis:

Process:

After 50 ml samples were taken from standard solutions, blank samples and samples to be analyzed. 2 ml of Alcoholic Phenol solution, 2 ml of Sodium Nitrosoprussiate solution and 5 ml of Oxidation Reagent were added to them. After it is closed and kept in a dark place for 1 hour, its absorbance was determined with a spectrophotometer at 640 nm. The amount of NH_4^+ in the water is determined by using the calibration chart.

Phosphate (PO_4) Analysis

Process:

After 50 ml of standard solutions, blank sample and samples to be analyzed are taken, 5 ml of reagent mixture was added and mixed well, waited for 10 minutes and absorbances were determined with a spectrophotometer at 700 nm. After the factor was found, the amount of phosphate in the seawater was determined according to the formula.

Water Quality Analysis:

During the experiment, water samples will be taken from the units, water temperatures was measured with the help of a thermometer that is sensitive to ± 0.1 ºC, pH values were calculated with a pH meter, and salinity ($\%_0$ S) was measured with the help of a Refractometer. Dissolved Oxygen determination was measured with the help of an Oxygen-meter.

Ulva Biomass Analysis:

During the experiment, biomass data were recorded by measuring the wet weight of the *Ulva* on an electronic precision scale (Japanese Shimatza) after removing the sea water with the help of a paper towel. Specific growth rates were calculated using the formula below:

Specific Growth Rate: (100 ln (Nt / No)) /t

Where, N_o: initial weight and N_t: weight on day t (Cirik and Gökpınar, 1999).

Statistical Analysis:

All data from the experiments were analyzed using the ANOVA procedure in the SPSS program (Özdamar, 2009). All data are presented as mean± standard deviation. Values related to the biomass and the amount of nutrients among the experimental treatment groups were compared by applying Duncan's Multiple Comparison Test (Özdamar, 2009) in the SPSS program, and $p \leq 0.05$ values were considered statistically different.

RESULTS

Nutrient Removing Capasity of Ulva rigida

The amounts of Ammonium, Nitrite, Nitrate, and Phosphate in the water of treatment groups at the beginning and at the end of the experimental period where *Ulva rigida* kept for a week were given in Table 1.

Table 1. Nutrient removing capacities (µgat.L^{-1}). of *Ulva rigida* cultivated at different experimental treatment groups (N=3).

Treatment 1: Received only Conway Culture Medium	**At the beginning of the experiment (µgat.L^{-1})**	**At the end of the experiment (µgat.L^{-1})**	**Removing capacity of the Nutrients**
Ammonium (NH_4)	$0.25^{a} \pm 0.00$	$0.10^{b} \pm 0.00$	60 %
Nitrite (NO_2)	$0.20^{b} \pm 0.00$	$10.00^{a} \pm 0.00$	increased
Nitrate (NO_3)	$102.00^{a} \pm 0.00$	$50.00^{b} \pm 0.00$	51%
Phosphate (PO_4)	$90^{a} \pm 0.00$	$50.00^{b} \pm 0.00$	45%
Treatment 2: Received 25% Fish Effluent water			
Ammonium (NH_4)	$0.175^{b} \pm 0.00$	$0.25^{a} \pm 0.00$	increased
Nitrite (NO_2)	$0.175^{b} \pm 0.00$	$10.00^{a} \pm 0.00$	increased
Nitrate (NO_3)	$1.25^{b} \pm 0.00$	$7.50^{a} \pm 0.00$	increased
Phosphate (PO_4)	$10.00^{a} \pm 0.00$	$5.00^{b} \pm 0.00$	50%
Treatment 3: Received 50% Fish Effluent water			
Ammonium (NH_4)	0.35 ± 0.00	0.25 ± 0.00	29%
Nitrite (NO_2)	0.35 ± 0.00	0.05 ± 0.00	86%
Nitrate (NO_3)	2.50 ± 0.00	17.00 ± 0.00	increased

Phosphate (PO_4)	20.00± 0.00	15.00 ± 0.00	25%

*Different letters shows statistical differences between the treatment groups ($P\leq0.05$).

Relative Daily Growth Rate and Biomass Yield of Ulva rigida

The Relative daily growth rates (% biomass.day^{-1}) of *Ulva rigida* cultivated in different experimental treatment groups were given in Table 2.

Table 2. The relative daily growth rates (% biomass.day^{-1}) of *Ulva rigida* cultivated in different experimental treatment groups (N=3).

Experimental Treatment groups	Control Group received only Conway Culture Medium	Received 25% Fish Effluent water	Received 50% Fish Effluent water
Relative Growth Rate (% biomass. Day^{-1})	1.36^{b*} ± 0.00	1.36^{b} ± 0.00	4.80^{a} ± 0.00

*Different letters shows statistical differences between the treatment groups ($P\leq0.05$).

Water Quality Parameters during the experimental conditions

During the experimental period, the water quality parameters such as temperature, salinity, PH and dissolved oxygen levels were given in Table 3.

Table 3. The water quality parameters during the experimental period (N=7).

Experimental Treatment Groups	Temperature (^{0}C)	Salinity (‰)	PH	Dissolved Oxygen (mg.L^{-1})
Treatment 1 (Control Group)	25.12 ± 1.83	35.60 ± 0.80	8.50 ± 0.40	8.75 ± 0.55
Treatment 2 (25% Fish effluent water)	25.41 ± 1.72	35.42 ± 0.50	8.75 ± 0.15	8.76± 0.65
Treatment 3 (50 % Fish Effluent water)	25.15 ± 1.32	35.30 ± 0.50	8.30± 0.40	8.50± 0.50

Discussion and Conclusion

Present study results showed similarities to the previous research studies (Neori et al., 1991, 2003; Shipigel et al., 1993; Schuenhoff et al., 2003). As a conclusion, the potential for use of nitrophilous macroalgae species such as *Ulva rigida*, which is distributed along the Aegean coast of Türkiye, in water treatment in aquaculture systems has been determined. In future studies, issues such as the use of other nitrophilous algae species as biofilters and the establishment of species protocols for optimum efficiency, water purification with macroalgae species and system selection, determination of fish-macroalgae density and water purification efficiency, and evaluation of the obtained algal biomass are topics that need to be studied intensively. When these studies and their results are combined, it will be possible to develop water treatment systems based on macroalgae, environmentally friendly integrated fish farms, and the algae industry.

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Length-based assessment method for the improved management of *Sander lucioperca* (Linnaeus, 1758) fisheries in the continental waters of Carp Sperm

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Abstract

The pike perch, *Sander lucioperca* is one of the most heavily exploited fish species, serving as the main catch in the fisheries of Al Massira Reservoir. Despite this severe exploitation, no information is available on the species' population status in Morocco, indicating the urgency of developing assessment studies to aid in the implementation of conservation plans for their stocks. Therefore, this study seeks to assess the population status of pike perch collected in the Al Massira Reservoir based on length composition data, using the package "TropFishR". As evident from the yield-per-recruit analysis (Y'/R), the observed exploitation rate value for the species (E = 0.55) exceeds the maximum exploitation rate (Emax = 0.41), indicating that the *Sander lucioperca* stock is overexploited in the Al Massira Reservoir. Moreover, this exploitation rate (E = 0.55) exceeds the optimal reference rate (E = 0.5), thus reinforcing the evidence of overexploitation. The estimated fishing mortality in the present study (F = 0.31 year^{-1}) is greater than the maximum mortality (Fmax = 0.23 year^{-1}), further confirming that the *Sander lucioperca* population is subject to excessive fishing pressure. This situation calls for an immediate intensification of monitoring programs for the species' population as a pre-requisite to develop efficient management and conservation plans in the continental waters of Morocco.

Keywords: *Sander lucioperca,* Al Massira Reservoir, population status, exploitation rate, fishing mortality.

Risk assessment of Microplastic Contamination in Qarasoo Basin, Southern Caspian Sea

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Abstract

Concerns about the negative effects of microplastics on human health have led to increasing attention to the occurrence of microplastics in the aquatic environments. Recent studies have focus from the marine environment to inland waters, particularly the spatio-temporal distribution of microplastics in rivers. Qarasu basin, leading to Gorgan Bay, is the site of many permanent rivers and the levels of microplastic pollution in those rivers are unknown. This study was conducted along 8 different rivers in 2020. Some 9 fish species were identified and the presence of microplastics was confirmed in 87% of fish. The prevalence of microplastic particles among species were *Chelon* spp.> *Carassius gibelio*> *Gambusia holbrooki*> *Rutilus rutilus*> *Neogobius melanostomus*> *Cyprinus carpio* = *Vimba persa*> *Rutilus caspicus*> *Barbus cyri*. The highest type, color and size of fish microplastics were fiber, black, 0.5-0.1mm, respectively. In conclusion the rivers of Qarasu basin have been polluted by microplastics not only in developed areas with intense human activity but also in upstream areas, which can be considered as a source of pollution in Gorgan bay.

Keywords: Microplastics, Qarasu basin, Fish, Sediments

Bridging the gap between fishponds management and avian conservation: the case of Dumbrăvița fishing complex – the most important stopover for Black Storks in Romania

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Abstract

The extent to which artificial wetlands provide resources and good-quality habitats for long distance migrants during stopovers has long been a debated topic, considering the constant loss and fragmentation of natural habitats. In the case of Black Storks (*Ciconia nigra*, an umbrella species, listed as Vulnerable in Romania), the increased usage of man-managed ponds during passages seems to have tailored to the species migration costs. Our study aims to assess and build up site potential for an important fall passage stopover for Black Storks in Central Romania: Dumbrăviţa Fishing Complex (a semi-intensive aquaculture system).

Monitoring of 6 successive fall passages (August-September; 2013-2018) focused on the Black Stork's evening foraging (4-6 P.M.). Point counts provided data for population abundance. We considered both water drainage and migratory patterns. Additionally, afternoon feeding sessions were recorded weekly during 2017-2018. Behavioral patterns were analyzed via focal and scan sampling methods (resulting in 168 10-minutes feeding bouts).

Both foraging patterns and species dynamics were subject to water-level management. Black Stork's stopovers at Dumbrăvița were conditioned by alternative pond drainage. Drainage starting date for large ponds swayed peak dynamics (in accordance with the species' migratory patterns) and passage-synchronized water discharge supported higher peaks. Evening foraging activity patterns were dependent on harvesting practices, while the hunting strategies employed were water-level related. Significant number increases (over the last 20 years) underscored that, hitherto, the local fish farming has unintentionally provided for the species foraging needs. To secure the stopover's potential for Black Storks, we set forth several management recommendations.

Keywords: *Ciconia nigra*, water-level management, long-term conservation strategies

Evaluation of the Effects of Experimental Parameters on Turbidity Removal from Leachate Water by Electrocoagulation Process

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Abstract

Since leachate is a complex and highly variable wastewater, it is the most difficult to treat in wastewater. Electrochemical processes are among the most preferred methods in leachate treatment. These processes show simple equipment, ease of use, robustness, versatility and sensitivity to automation. Electrocoagulation (EC) is a wastewater treatment process used to destabilize colloidal suspensions that cause agglomeration of pollutants by using electrical energy to dissolve metals such as aluminum and iron. The most preferred electrode materials are aluminum and iron, as they are economical, effective and easily soluble in the electrocoagulation process. In the case of using aluminum electrodes, it produces Al^{3+} and $Al(OH)^{2+}$ species, which are initially converted to $Al(OH)_3$ and subsequently converted to $Al_n(OH)_{3n}$ as a result of the electrolytic dissolution of the aluminum electrode. In this study, the effects of current density, initial pH, distance between electrodes, mixing speed and initial temperature on turbidity removal efficiency were investigated in the removal of turbidity from leachate by electrocoagulation process. Experimental studies were used in a 20cmx8cmx10cm reactor made of plexiglass. The electrodes are arranged in a monopolar parallel arrangement with three anodes and three cathodes. In electrochemical processes, 400 mL samples taken from filtered and 1/4 diluted raw leachate were placed in the reactor. Samples were taken at different time intervals during the 40-minute application time. Aqualytic brand AL250T-IR model turbidimeter was used for turbidity analysis of the samples. In the experiments, turbidity

removal efficiencies were determined according to current density 15-25 mA/cm^2, pH 3-9.5, temperature 20-60ºC, stirring speed 100-300 rpm, distance between electrodes 1-2 cm. In the light of the data obtained, the highest turbidity removal efficiency was determined as 62% at current density 20 mA/cm^2, pH 5, initial temperature 20°C, distance between electrodes 1 cm, stirring speed 300 rpm. It can be said that this is due to the tendency of aluminum to hydrolyze and adsorb colloidal structures on the surface of the electrode. Thus, it can be said that the electrocoagulation process is a suitable process for turbidity removal from leachate.

Keywords: Electrocoagulation, leachate, turbidity removal, Al electrod.

Introduction

The rapid increase in population and urbanization has led to a surge in solid waste production, posing significant challenges for environmental protection and sustainability (Mojiri et al., 2017). Landfill leachate, characterized by high concentrations of organics, heavy metals, and recalcitrant pollutants, remains a pressing concern despite efforts to reduce waste generation and prevent pollution (Wang et al., 2009). The composition of landfill leachate varies depending on factors such as the age of the landfill, the types of waste present, and environmental conditions. Typically, landfill leachate contains high concentrations of organic compounds, such as volatile fatty acids, phenols, and ammonia, along with heavy metals like lead, cadmium, and mercury Guo et al., 2010). Additionally, it may contain pathogens and other hazardous substances, making it a significant environmental concern (Abood et al., 2014). Leachate properties vary significantly based on landfill age, with young leachates exhibiting high concentrations of biodegradable compounds and mature leachates containing recalcitrant compounds such as humic substances. Landfill leachate poses several environmental risks (Bu et al., 2010). When it seeps into the surrounding soil and groundwater, it can contaminate drinking water sources and harm ecosystems. The release of pollutants from leachate can lead to soil degradation, surface water pollution, and the impairment of aquatic habitats. Moreover, the presence of organic matter in leachate can contribute to the generation of greenhouse gases, such as methane, exacerbating climate change. Various treatment methods are employed to mitigate the environmental impact of landfill leachate. Common techniques include physical processes like filtration and sedimentation, biological processes such as aerobic and anaerobic treatment, and chemical processes like coagulation, oxidation, and adsorption. Various treatment methods, including aerobic and anaerobic processes, flotation, coagulation-flocculation, and chemical precipitation, have been employed for leachate treatment (Li et al., 2010). While aerobic and anaerobic biodegradation processes are cost-effective, they may pose environmental risks, particularly when treating young leachates. Hence, alternative technologies like electrocoagulation (EC), electrochemical oxidation (EO), and advanced oxidation processes have gained attention due to their efficiency and lower operating costs. Advanced treatment technologies, including membrane filtration, ultraviolet (UV) disinfection, and advanced oxidation processes (AOPs), are also utilized to remove contaminants from leachate effectively (Li et al. 2009). Despite advancements in leachate treatment, challenges remain, particularly concerning the management of older landfills and the treatment of recalcitrant pollutants. Additionally, the increasing volume of waste generation and the emergence of new contaminants present ongoing challenges for leachate management. Moving forward, there is a need for continued research and innovation to develop more sustainable and cost-effective solutions for landfill leachate treatment, ultimately minimizing its environmental footprint and safeguarding human health and the environment. In EC, differences in electric potentials generate coagulants, facilitating the removal of contaminants such as COD, nitrogen, phosphorus, turbidity, and color from wastewater. Basic reactions occurring at the anode and cathode involve the electrolytic dissolution of aluminum electrodes, producing cationic species that aid in coagulation (Mechelhoff et al., 2013)

The basic reactions that occurs in an EC cell are described in Equations (1)-(3).

At the anode: $M_{(s)} \rightarrow M^{n+}_{(aq)} + ne^-$ (1)

At the cathode: $2H_2O + 2e^- \rightarrow 2OH^- + H_2$ (2)

In the bulk solution: $M^{n+}_{(aq)} + nOH^- \rightarrow M(OH)_{n(s)}$ (3)

Where $M_{(s)}$ = metal, $M^{n+}_{(aq)}$ = metallic ion (aluminum ion), $M(OH)_{n(s)}$= metallic hydroxide, and ne^- =the number of electrons transferred in the reaction at the electrode. It should be noted that equation (3) describes a simple case of metallic hydroxide formation. In fact, depending on the pH level and the relevant metal, a wide range of complex metallic species can form (Dia et al., 2016). Electrocoagulation emerges as a promising method for landfill leachate treatment, offering efficiency and cost-effectiveness compared to traditional techniques. By optimizing process parameters, we can enhance turbidity removal and mitigate environmental impacts associated with landfill leachate discharge. This research contributes to the development of sustainable solutions for managing wastewater from landfills, promoting environmental stewardship and resource conservation (Dia et al., 2018).

This study aims to investigate the effects of process parameters on turbidity removal during landfill leachate treatment using the EC process with aluminum electrodes. Parameters such as process performance, initial pH, electrolyte concentration, and inter-electrode distance will be examined and optimized.

Material and methods

The raw landfill leachate

The landfill leachate used in this study was sampled from a municipal landfill located in the province of Bingol, Turkey. The leachate was collected (without any filtration) in plastic containers and kept in the laboratory at 4°C before experiments. Characteristics of leachate were given in Table1 and then analyzed as per standard methods (APHA, 2012).

Table 1. Characteristics of landfill leachate

Parameter	Unit	Value
pH		8.35
Conductivity	mS/cm	47
Total solids	mg/L	7700
Total volatile solids	mg/L	2871
Suspended solids	mg/L	221
Volatile suspended solids	mg/L	35
TDS	mg/L	6654
COD	mg/L	4175
BOD_5	mg/L	1650
chloride	mg/L	2872
BOD_5/COD	mg/L	0.4
NH_3-N	mg/L	2438.7
Turbidity	NTU	228

Electrocoagulation system setup

The basic EC setup used in this work is presented in Fig. 1

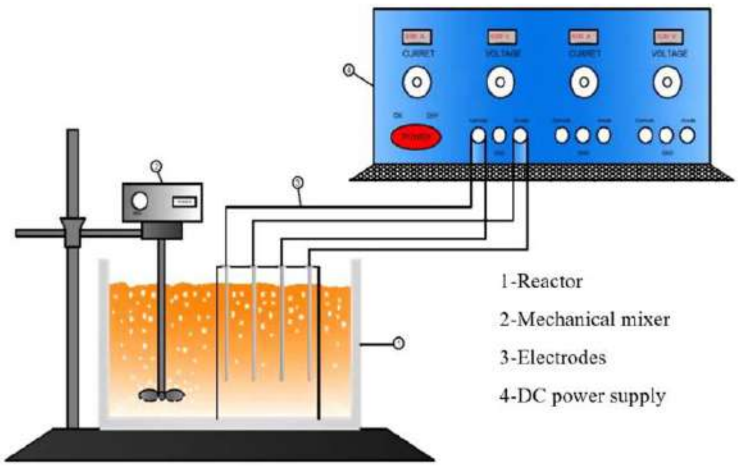

Figure 1. Electrocoagulation process

Aluminum electrodes with an effective surface area of 25 cm^2 were immersed in the 500 m reactor. In this study, 1/4 diluted leachate was used. A reactor made of plexiglass with dimensions of 20cm x 8cm x 10cm was used in the processes. It consists of aluminum metal sheets as anode and while the cathode was in stainless steel. The electrodes are arranged in a monopolar parallel arrangement with three anodes and three cathodes. To ensure complete mixing, it was mixed throughout the experiment period by a

Daihan brand HS-30D model mechanical stirrer immersed into the reactor from the top. In experiments, current density was 15 - 25 mA/cm^2, pH 3 - 9.5, temperature 20 - 60^{o}C, stirring speed 100 - 300 rpm, distance between electrodes 1 - 2 cm removal of turbidity yield values at the end of sampling intervals of 1, 3, 5, 10, 15, 20, 25, 30, 35 and 40 minutes.

Calculation

The normalized turbidity concentration is defined as the ratio of turbidity concentration at time t (C, mg/L) to the turbidity concentration of influent (C_0, mg/L). The removal efficiency (RE) of turbidity is defined as:

$$RE = \frac{C_0 - C}{C_0} \ x \ 100\% \quad (4)$$

Results

Performance of the EC in turbidity removal

Influence of current density

Current intensity is the most important parameter of EC process. This parameters define the amount of coagulant (Al^{3+}) introduced in the reactor. In order to determine the best conditions for turbidity removal in terms of current density, different values of these parameters were applied on the raw landfill leachate. The obtained results are presented in Fig. 2.

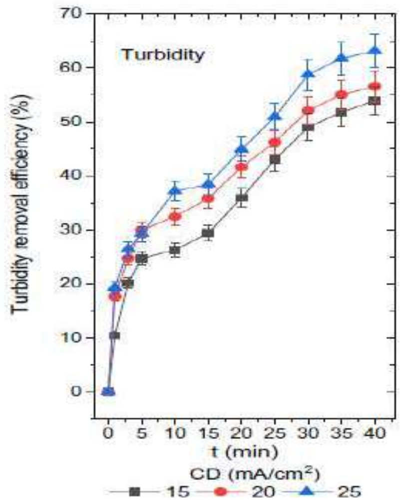

Figure 2. Changes in the concentration of turbidity and the efficiency of leachate removal at various levels of current density in the electrocoagulation process.

From this figure, it can be seen that, for the low current densities (15 – 25 mA/cm^2), the turbidity elimination increased when the current density increased. Results showed that current density at 25 mA/cm^2, up to 63% turbidity removal efficiency was achieved.

Influence of initial pH

pH plays a very important role in determining treatment efficiency. Therefore, experiments were designed to determine the optimum pH of leachate that allowed for maximum turbidity reduction. The effect of pH on the treatment efficiency was examined by altering the initial pH from 5 to 9,5 and keeping all other parameters (current density = 25 mA/cm^2, reaction time = 40 min., temperature = 20°C, stirring speed = 200 rpm, distance between electrodes = 1 cm) constant. The turbidity removal efficiency increased by decreasing the pH to 5 and then decreased by increasing the pH to 9,5. Results showed that at pH 5, up to 62% turbidity removal efficiency was achieved in Fig. 3.

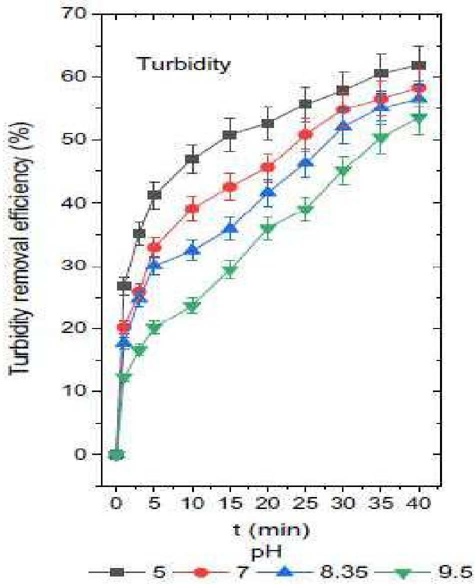

Figure 3. Changes in the concentration of turbidity and the efficiency of leachate removal at various levels of pH in the electrocoagulation process.

From this figure, in acidic pH, cationic monomeric species Al^{3+} and $Al(OH)^{2+}$ prevail. When pH is between 4 and 9, various monomeric species such as $Al(OH)^{2+}$, $Al(OH)_2^{2+}$, and polymeric species such as $Al_6(OH)_{15}^{3+}$, $Al_7(OH)_{17}^{4+}$,$Al_{13}(OH)_{34}^{5+}$ transform into insoluble amorphous $Al(OH)_{3(s)}$ flocs through complex polymerization and/or precipitation mechanism. When pH is higher than 8, the monomeric $Al(OH)^{4-}$ concentration increases, decreasing the significance of insoluble amorphous $Al(OH)_{3(s)}$ flocs (Verma, 2017).

Influence of initial temperature

Based on the necessity of the obtaining of this fundamental information related to the high-temperature application of the electrocoagulation, this study was carried out to determine the effect of the the varying suspension temperatures between 20 - 60 °C on the electrocoagulation performance of turbidity removal. Results showed that at 50 °C, up to 62% turbidity removal efficiency was achieved in Fig. 4.

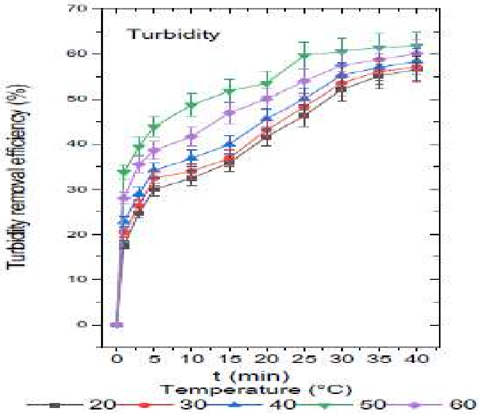

Figure 4. Changes in the concentration of turbidity and the efficiency of leachate removal at various levels of temperatures in the electrocoagulation process.

From this figure, it can be seen that, with increasing temperature, turbidity removal efficiency from leachate wastewater increased (Chen, 2004). Increasing the solution temperature accelerates and increases the dissolution of Al^{3+} ions dissolved in the aluminum anode, and the resulting Al^{3+} hydrolyzes into monopolymers and $Al(OH)_3$ solid (Al-Raad et al., 2020).

Influence of inter-electrode distance

Inter-electrode distance is an important variable with regards to operational costs. The effect of the distance between electrodes on turbidity removal from leachate with Al electrode is shown in Figure 5.

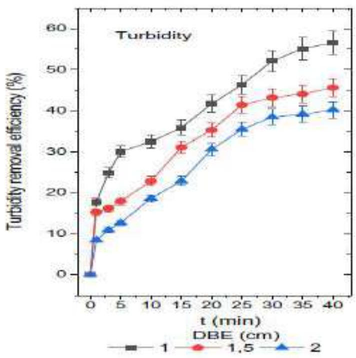

Figure 5. Changes in the concentration of turbidity and the efficiency of leachate removal at various levels of inter-electrode distance in the electrocoagulation process.

Fig. 5 depicts that turbidity removal efficiency is improved by decreasing the distance between the anodes and cathode (i.e., increasing the distance between two anodes). This can be attributed to the increase of electrical current associated with reducing the inter-electrode distance resulting in higher collisions of the ions that enhance the coagulation. Maximum turbidity reduction efficiency of 57% was attained with a distance of 1 cm between the two anodes.

Discussion

Landfill leachate comprises a mixture of diverse toxic compounds that are challenging to treat using conventional methods. This paper explores the application of electrocoagulation (EC) for leachate treatment, which leverages both sedimentation (induced by anode-released coagulants) and flotation (facilitated by cathode-generated hydrogen bubbles). The impacts of initial pH (5.0−9.5), electric current intensity (15−25 mA/cm^2), initial temperature (20−60°C), and Inter-electrode distance (1−2 cm) were investigated on turbidity removal. The best performance was obtained at a pH of 5, current intensity of 25 mA/cm^2, and reaction time of 40 min with an initial temperature of 20°C, leading to turbidity removal of 62%. This also provides an opportunity to further expand research into the use of aluminum electrodes for treating leachate. The findings of this study affirm that aluminum can serve as an electrode in electrocoagulation (EC) for treating leachate, resulting in enhanced water quality.

Conclusions

Electrocoagulation is a highly effective method for eliminating color and organic pollutants from wastewater. The electrocoagulation treatment of leachate was influenced by factors such as current density, initial pH, initial temperature, and initial inter-electrode distance. Our experimental results demonstrated that the highest COD removal of 62 % was achieved at a current density of 25 mA/cm^2, a pH of approximately 5, an initial temperature of 20°C, and an inter-electrode distance of 1 cm. Meanwhile, the results indicated that electrocoagulation effectively and rapidly removed leachate.

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Current Status in Carp Sperm Cryopreservation

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Abstract

Carp species is one of the most significant freshwater fish for both ecology and economy and is found all over the world. Roughly 9% of all aquaculture productivity comes from carp species in 2020. Since the 1970s, cryopreservation protocols for carp sperm have been developed. Fish sperm cryopreservation **is an effective method for offering a steady supply of high-quality sperm for genetic breeding, sustainable aquaculture development, and the preservation of fish germplasm supplies.** Generally, sperm is stored in liquid nitrogen at a temperature of -196 °C. **This method enables the total cessation of sperm's normal life activities and metabolic processes, achieving the goal of long-term preservation.** The aim of this review is to summarize the current status of sperm cryopreservation in carp species and evaluate the protocols used during the cryopreservation process of carp species. Aspects to be reviewed include the types and concentrations of extenders used, types and concentrations of cryoprotectants used, and research outcomes related to the motility, viability, and fertility of carp species. This review will focus on the needs and opportunities for cryopreservation research in carp species.

Keywords: Carp spesies, cryopreservation, extender, cryoprotectant

Introduction

Sperm quality is crucial for successful fertilization and normal embryo development and can be influenced by various factors including stress, environmental conditions (such as temperature, photoperiod, and salinity), as well as the diet of broodstock fish and timing of reproduction (Seçer et al., 2004; Bobe and Labbe, 2010)..

Carp species is one of the most significant freshwater fish for both ecology and economy and is found all over the world. Roughly 9% of all aquaculture productivity comes from carp species in 2020. Since the 1970s, cryopreservation protocols for carp sperm have been developed (Bozkurt et al., 2016). Sperm cryopreservation is the process of freezing and storing sperm cells at very low temperatures to maintain their viability and fertility for a specific period. Sperm cryopreservation has the potential to alleviate problems related to off-season productions, asynchronous spawning in cross-species and strain cross-breeding, planned crossings in selective breeding projects, and biosecurity requirements (Kutluyer et al., 2014). Sperm preservation techniques are broadly categorized into short-term storage, where unfrozen gametes are typically maintained at 4°C, and long-term storage through cryopreservation, involving immersion in liquid nitrogen at -196°C. The success of these methods hinges on several critical factors: atmospheric conditions, choice of diluents, precise temperature regulation, optimal dilution rates, and the incorporation of additives like cryoprotectants. Cryopreservation extenders for sperm commonly include two types of cryoprotectants: non-permeating agents such as milk, egg yolk, soybean lecithin, or raffinose, and permeating agents like glycerol or dimethyl sulfoxide. These substances are essential in safeguarding sperm cells during freezing and thawing processes. Antioxidants play a vital role in sperm cryopreservation by combating the detrimental effects of reactive oxygen species (ROS). However, their effectiveness can diminish due to dilution or cooling, which may compromise the sperm's natural antioxidant defenses (Kutluyer et al., 2015). Therefore, antioxidants are strategically utilized to preserve sperm viability and fertility by minimizing oxidative stress during cryopreservation. In this review, current status were presented about carp sperm cryopreservation.

Sperm cryopreservation

Cryopreservation plays a crucial role in protecting endangered species and preserving gametes of commercially important fish species for future use. Sperm, being small in size and resilient to cryogenic conditions, has been the primary focus of cryopreservation research in fish, both in laboratory settings and aquaculture. Over the past decade, specialized techniques for freezing sperm have been developed for numerous fish species, with ongoing investigations expanding the scope of these efforts across diverse aquatic organisms (Asturiano et al., 2017).

Historically, much of the global research on cryopreservation has concentrated on sperm cells from specific fish species, notably salmonids, carp, sturgeon, and catfish. Recently, there has been notable progress in studying marine species and various freshwater finfish species. Concurrently, there has been significant research into short-term storage methods, particularly focusing on carp. Below, the recent findings from these studies are compiled for reference.

Studies on Carp Sperm Cryopreservation

Cyprinid fish, particularly carp (*Cyprinus carpio*), play a crucial role in the sustainability of aquaculture in countries primarily focused on carnivorous species. As concerns grow over the depletion of natural fish stocks used for fish meal and oil, essential for carnivorous species' nutrition, authorities warn of impending collapse. To mitigate these risks, increasing the cultivation of omnivorous and herbivorous species alongside carnivorous ones is pivotal. This approach supports both sustainable human food supply and the conservation of natural fish stocks (Avlar and Bozkurt, 2022).

Cryopreservation requires the use of extenders and cryoprotectants to protect sperm cells from shock, which can also affect seminal plasma. The addition of cryoprotectants and the processes of freezing and thawing can damage sperm cells, leading to decreased fertilization rates. Therefore, comprehensive evaluation of different extenders and cryoprotectants is essential in sperm cryopreservation to develop optimal protocols tailored to each species (Hu & Tiersch, 2011). Globally, studies on fish sperm cryopreservation focus on exploring the variety of extenders and determining the appropriate dilution rates of cryoprotectants, crucial considerations both during and after freezing.

Li et al. (2013) utilized dimethyl sulfoxide (DMSO) and ethylene glycol (EG) based extenders for sperm cryopreservation. Their study involved processes of equilibration, freezing, and thawing, and they observed significant alterations in the phosphorylation state of sperm proteins on tyrosine or threonine residues with both DMSO and EG extenders.

Öğretmen and İnanan (2014) stated that concentrations of BHT exceeding 1 mM were found to induce sperm immobility during the initial stages of sperm freezing. The researchers concluded that BHT concentrations ranging from 0.001 to 0.1 mM can be advantageous for the sperm cryopreservation

Öğretmen et al. (2014) determined that extenders containing propolis significantly improved both the percentage of motile sperm and the duration of motility compared to the control group ($P < 0.05$). Specifically, group IV (0.8 mg/ml propolis) and group V (1 mg/ml propolis) showed significant positive effects on post-thaw motility and hatching ability, indicating that propolis supplementation enhances the cryopreservation outcomes of sperm.

Öğretmen et al. (2015) showed that the optimal concentration of cysteine for cryopreservation was 20 mM, yielding the highest post-thaw motility (76.00 ± 1.00%) and fertilization rates (97.00 ± 1.73%) compared to other concentrations tested. This finding suggests that using an extender containing 20 mM cysteine enhances both sperm motility and fertilization outcomes after cryopreservation.

Yildiz et al. (2015) reported that cryopreserved carp sperm containing 1.5 mg of cholesterol-loaded cyclodextrin (CLC) resulted in significantly higher fertilization success compared to extenders containing 0.5 mg, 2.5 mg, and 3.0 mg of CLC, as well as compared to the control group. Their study concluded that the treatment with cholesterol-loaded cyclodextrin notably enhances the cryosurvival of carp sperm cells.

Bernáth et al. (2016) reported that using a sugar-based extender, specifically the grayling extender, at ratios of 1:9 and 1:20, resulted in the highest sperm motility and VCL (curvilinear velocity). At a ratio of 1:9, motility was recorded at 52% with a VCL of 76 µm/s, and at 1:20, motility was 49% with the same VCL of 76 µm/s. They also developed a method utilizing a programmable freezer that proved effective for cryopreserving a higher number of straws.

Shaliutina-Kolešová et al. (2020) investigated the effects of treatment with fractions 1, 2, 3, and 4 on spermatozoa motility and velocity compared to an extender-only control. They found that all fractions significantly increased sperm motility rate and curvilinear velocity, with the highest values observed in fraction 4 (78.21 ± 2.41% motility and 168.05 ± 4.46 µm/s velocity). Additionally, fraction 4 resulted in significantly lower levels of DNA damage, measured as percent tail DNA (12.23 ± 1.27%) and olive tail moment (0.68 ± 0.12), compared to other fractions and the control.

İnanan and Kanyılmaz (2020) determined that after 120 hours of incubation, the 0.5 mM ALA group exhibited total spermatozoa motility at 80 ± 3% and viability at 87 ± 3%. In contrast, post-thaw samples from the 1 mM ALA group showed higher percentages for these parameters, with motility at 74 ± 3% and viability at 83 ± 2%.

Marinović et al. (2021) reported that both fresh and cryopreserved spermatozoa, when washed with fresh extender post-thawing, showed significant motility decreases after 24 hours at room temperature and 72 hours at 4°C. In contrast, cryopreserved spermatozoa maintained in their original cryomedium exhibited a rapid decline in motility within just 2 hours of storage.

Pataki et al. (2022) stated that the highest concentration tested, 4 × 10^9 spermatozoa per ml, achieved a fertilization rate of 66 ± 6%, which was significantly higher compared to the fertilization rate of 49 ± 5% at the pre-set dilution ratio. This study demonstrates that both spectrophotometry and CASA (Computer-Assisted Sperm Analysis) are effective methods for assessing common carp sperm concentration. Moreover, maximizing sperm concentration before cryopreservation leads to improved fertilization rates.

Sotnikov et al. (2023) demonstrated that increasing spermatozoa concentration to 13×10^{-9} spz mL^{-1} led to a notable decrease in post-thaw sperm motility percentage to 20%, compared to 39% at 0.5 × 10^9 spz mL^{-1}. This highlights the need either to adjust sperm concentrations per egg or enhance fertilization methods for better outcomes.

Conclusions

In conclusion, carp spermatozoa possess a remarkable ability to withstand cryopreservation at higher concentrations compared to other fish species. This resilience is thought to be influenced by species-specific characteristics such as cell size and the spermatozoa's capacity to endure mechanical stress. However, the exact mechanisms behind this phenomenon remain to be thoroughly explored in future studies. There is a growing interest in improving the cryopreservation success of concentrated carp sperm through tailored cryoprotective solutions and optimized freezing techniques, aiming to advance the efficiency of carp sperm cryopreservation technology.

Ethical approval

The author declares that this study complies with research and publication ethics.

Data availability statement

The authors declare that data are available from authors upon reasonable request.

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Carbon Footprint in Fisheries and Its Importance for Sustainability

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Abstract

Climate change which can no longer be ignored on a global scale, is defined as the excessive accumulation of greenhouse gases in the atmosphere and oceans, causing changes in ecosystems. With greenhouse gases exceeding threshold values, countries have taken steps to correct the disadvantageous situation in ecosystems and set a target zero emissions by 2050 with the Paris Climate Agreement. In order to restructure the sectors in line with this target, the first step is to determine the carbon footprint and to initiate the recovery processes. Carbon footprint and emission reduction efforts are at the center of international trade, not only on an ecosystem basis.

This study aimed to review the carbon footprint studies in fisheries, an important sector in terms of food security and employment, and to highlights its importance in terms of sustainability. Standards developed by the World Meteorological Organization and the United Nations are used to measure greenhouse gas emissions from fisheries to provide scientific information that can be used to develop climate policy. To date, carbon footprint studies have been carried out for different fisheries sub-segments in many seas. In Türkiye, studies on the assessment of the carbon footprint of the fisheries sector are limited. Increasing the number of studies on this subject and determining the emissions of the sector is of great importance in terms of the measures to be taken in a short time.

Keywords: Carbon footprint, Fisheries, Sustainability, Türkiye

1. Introduction

Climate change, which manifests itself as an important problem of the world, refers to "the changes in the global climate system and consequently in ecosystems due to the excessive increase in the accumulation of greenhouse gases in the atmosphere with anthropogenic effects" (Arıkan, 2016). The destructive effect of human-induced greenhouse gas accumulation has become visible after the industrial revolution.

Greenhouse gases provide the thermal balance of the atmosphere by retaining the radiation coming from the sun and reflected from the ground. In the 20th century, one of the main reasons for the warming of our atmosphere is the increase in the emission of various greenhouse gases as a result of human activities and consequently the warming of the earth by retaining more solar radiation (Bekiroğlu, 2011). Greenhouse gases are gases that absorb and re-radiate heat in the atmospheric layer and thus keep the atmosphere warmer than it should be. The main greenhouse gases are water vapour, carbon dioxide (CO_2), methane (CH_4), diazot monoxide (N_2O), hydrofluoride carbon (HFCs), perfluoro carbon (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3) gases (Brander & Davis, 2012). As can be seen in Table 1, depending on how many times more heat retention capacity of the six greenhouse gases specified in the Kyoto Protocol compared to the same amount of CO_2, emission calculations in a common denominator make emission calculations more understandable.

Table 1. Global Warming Potentials (GWP100) of main greenhouse gases (IPCC, 2007)

Species	Chemical Formula	GWP100
Carbondioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
HFCs	-	124 - 14800
Sulphur hexafluoride	SF_6	22800
PFCs	-	7390 - 12200

Unless the industry and energy sectors, which are responsible for 80% of atmospheric greenhouse gas compositions, are transformed, global warming effects will increase. For the transformation of the sectors, the priority process and target is to determine the carbon footprint and realise the improvement processes. Some steps have been taken by countries in recent years to achieve this target.

One of these steps is the Paris Agreement (PA), which determines the post-2020 global climate regime and is based on the voluntary contributions of countries in the fight against climate change. In line with the fact that the struggle is based on voluntary participation, criticisms have also been made that the free-rider problem in international climate agreements (not paying a price but benefiting from the resulting benefits) constitutes an obstacle to success. In response to these criticisms, a climate club approach has been introduced to increase the effectiveness of the agreement. Accordingly, it is aimed to increase the effectiveness of climate agreements through external sanctions to be imposed on countries outside the climate club.

Another step is the "European Green Deal" (EGD) adopted by the European Union (EU) countries in November 2019. The ECC was prepared in line with achieving the objectives of the Paris Agreement and is a step towards making the work to be done in this context a priority for governments.

The priorities of the European Green Deal for the environment and oceans include: Preserving our biological diversity and ecosystems, reducing air, water and soil pollution, transitioning towards a circular economy, improving waste management, ensuring the sustainability of our blue economy and fisheries sectors.

With the EGD, the EU offers the prospect of becoming a climate club of low-carbon countries. The main objectives of the EDG are to achieve zero greenhouse gas emissions on the European continent by 2050 and to decouple economic growth from resource use, transforming Europe into a fair and prosperous society with a modern, resource-efficient and competitive economy.

In the text of the agreement; in addition to the goal of making the European continent the first climate-neutral continent, topics and approaches such as clean, accessible and reliable energy, a fair, healthy and environmentally friendly food system with a farm-to-table strategy, a circular economy, a construction approach where resources are used efficiently, protection of ecosystems and biodiversity, smart transport, zero pollution, and financing arrangements that will leave no one behind are listed. The prerequisite for the funding support envisaged to be provided to countries by the EU, which constitutes the framework of the ECC, is based on the certification of the carbon footprint (Mirici & Berberoğlu, 2022). This agreement is also a sanction argument for the new international trade system and the revision of sectors that affect global climate change (Yeldan et al., 2020). Therefore, determining the environmental impacts of sectors (emission of greenhouse gases such as carbon, etc.) is an issue that has been emphasised in recent years.

In the fight against global climate change, a carbon price will be applied on imported goods by means of instruments such as the carbon border adjustment mechanism developed within the scope of the EGD to countries that cannot provide production with low carbon intensity and do not have carbon pricing mechanisms. Considering that 14 per cent of global imports are made up of EU imports and more than 40 per cent of Türkiye's exports are made to the EU, the issue becomes more important both globally and for our country (Anonymous, 2023).

This study aimed to review the carbon footprint studies in fisheries, an important sector in terms of food security and employment, and to highlights its importance in terms of sustainability.

2. Climate Change

There are three fundamental conditions for us to talk about climate change. First, it must be anthropogenic, second, greenhouse gases in the atmosphere must accumulate and finally, there must be a change in the ecosystem. The accumulation of greenhouse gases in the atmosphere causes the oceans to be affected by this situation. Excessive accumulation in the oceans causes acidification. Warming of ocean water and acidification cause permanent damage to the ecosystem. As a result of these causes, we see a decrease in fish populations and the replacement of these species with invasive and alien species.

Countries have been sensitive to climate change since the 1980s when the ozone layer began to get thinner. This sensitivity has continued through the "COP" (Conference of the Parties) meetings, leading up to and including the Paris Agreement.

3. Carbon Footprint

CO_2 is the gas that has the most impact on climate change. Composed of one carbon atom and two oxygen atoms, CO_2 is clear, chemically reactive and non-toxic. Although it is very low in concentration (0.04%), it is a vital component for living life in our world.

Since carbon emission is one of the important causes of global warming and climate change, determining the carbon emissions of the sectors under the name of carbon footprint is an issue that has been emphasised in recent years. Carbon dioxide (CO_2) is the most common GHG emitted by human activities, in terms of the quantity released and the total impact on global warming.

3.1. The Importance of Determining Carbon Footprint for Sustainability

According to World Meteorological Organisation reports, atmospheric concentrations of greenhouse gases reflect the balance between emissions from human activities and natural sources and sinks in the biosphere and ocean. Increasing levels of greenhouse gases in the atmosphere due to human activities have been the main driver of climate change since the mid-twentieth century.

Most of the excess energy accumulated in the Earth system due to increasing concentrations of greenhouse gases is taken up by the ocean. The added energy heats the ocean and the resulting thermal expansion of water causes sea level rise, which is further increased by melting ice. The surface of the ocean warms faster than the interior, and this can be seen in the rise in the global average temperature and the increased frequency of marine heat waves. As the concentration of CO_2 in the atmosphere increases, the concentration of CO_2 in the oceans also increases. This affects ocean chemistry and lowers the average pH of the water, a process known as ocean acidification. All these changes have a wide range of effects in the open ocean and coastal areas.

The ocean helps to mitigate the effects of climate change by absorbing around 23 per cent of the annual anthropogenic CO_2 emissions into the atmosphere. However, CO_2 reacts with seawater, lowering its pH. This process, known as ocean acidification, affects many organisms and ecosystem services, jeopardising fisheries and aquaculture and threatening food security. This is a particular problem in the polar oceans. It also affects coastal protection by weakening the coral reefs that protect coastlines. As the pH of the ocean decreases, its capacity to absorb CO_2 from the atmosphere decreases, reducing the ocean's capacity to mitigate climate change. Regular global observations and measurements of ocean pH are needed to improve understanding of the consequences of their variability, enable modelling and prediction of change and variability, and help inform mitigation and adaptation strategies. (WMO, 2021)

The amount of carbon dioxide in the atmosphere (blue line) has increased along with human emissions (gray line) since the start of the Industrial Revolution in 1750. Emissions rose slowly to about 5 gigatons—one gigaton is a billion metric tons—per year in the mid-20th century before skyrocketing to more than 35 billion tons per year by the end of the century (Figure 1) (Anonymous, 2024).

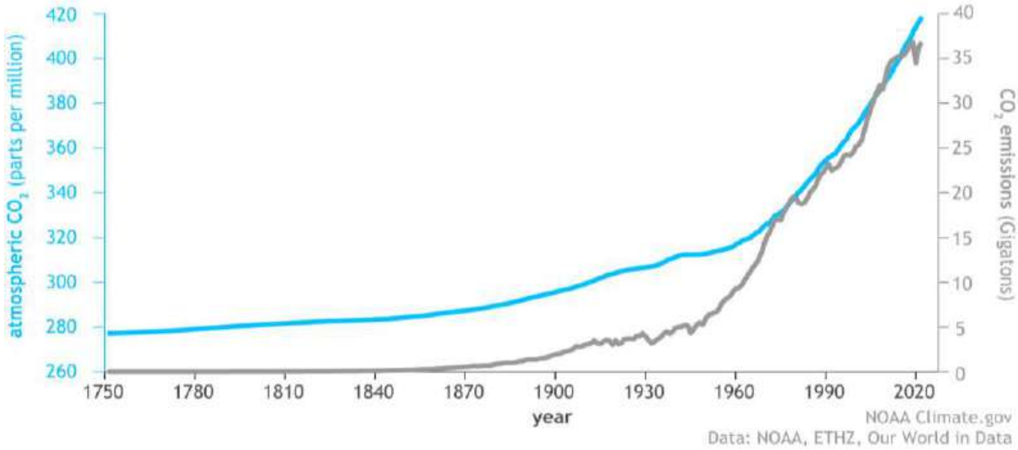

Figure 1. Global atmospheric carbon dioxide compares to annual emissions (1751-2022) (Anonymous, 2024)

Determining the inventory of CO_2 and other greenhouse gas emissions is a decisive factor in reducing the effects of global warming and thus climate change. For this reason, results can be observed by obtaining regular data in the realisation of that emission target. Energy transformation and emission reduction policies and methods can be implemented in a healthier way.

3.2. Carbon Footprint Determination Methods

In determining environmental impacts, two parameters, namely Carbon Footprint (CF) and Life Cycle Analysis (LCA), have come to the fore. Carbon Footprint (CF) consists of an estimate of the total amount of greenhouse gas emissions associated with a product along the supply chain (EPLCA, 2007). Therefore, the carbon footprint of a product refers to the GHG emissions of the assessed product throughout its life cycle, from raw materials to production, distribution, consumer use and disposal (Carbon Trust et al., 2008).

Life Cycle Assessment (LCA) is a standardized method for calculating the environmental impact of any product or service from the beginning to the end of its life, including its carbon footprint. It is defined and outlined by the international standardization organization in ISO 14044 and 14040. Like a CF estimate, it follows a product from the extraction of raw materials to its final disposal or recycling of waste. However, rather than focusing on a single impact category of global warming, it considers all possible environmental impacts associated with the product chain. This can range from global warming potential to habitat destruction, with a range of other impact categories in between (BSI, 2011).

CF is recognized as an important category of LCA and one of the main components of overall impact (BSI, 2011). Measuring carbon footprint is recognized by the UN Framework Convention on Climate Change as a key to contributing to the achievement of international climate action targets. It allows organizations to see more accurately where the main impacts on their carbon footprint occur and thus take appropriate measures to reduce it (Gabrieli and Jafarzadeh, 2020). CF provides a single index of environmental performance that can be easily understood. However, the concept of CF can be criticised for being one-dimensional as it focuses only on the impacts of climate change while completely excluding all other environmental aspects.

There are two types of methodological approaches for calculating CF. One is organisation-based and the other is product-based. The CF of a product is the total greenhouse gas (GHG) emissions produced during a defined system boundary (life cycle stages). GHGs are considered to be all gaseous substances for which Integrated Pollution Prevention and Control has defined a global warming potential expressed as mass-based CO_2 equivalents. The results from a GHG estimate will vary greatly depending on the methodology applied, for example the life stages and parameters included in the calculations.

Life cycle stages are defined by the following system boundaries:

-From cradle to grave/business to consumer includes emissions and removals generated throughout the entire life of the product cycle.

-From cradle to gate/business to business, includes emissions and removals up to the point where the product leaves the organization.

-Door-to-door includes emissions and removals in the supply chain.

-Partial CFA includes emissions and removals related to specific stages only.

There are three main CF standards applied worldwide: A) PAS 2050, B) ISO 14067 and C) the Greenhouse Gas Emissions (GHG) Protocol. These methods all provide requirements and guidelines for decisions to be made when conducting a carbon foot printing study and are based on existing Life Cycle Analysis (LCA) methods established through ISO 14040 and ISO 14044. Decisions include LCA topics such as target and scope definition, data collection strategies and reporting. Furthermore, these standards provide requirements on specific topics related to Carbon footprint (CF), including land use change, carbon uptake, biogenic carbon emissions, soil carbon exchange and green electricity (Skontorp & Ziegler, 2014).

Various comparisons have been made on accounting methods for various products. The use of different methods often leads to numerical differences in the CF value. The main issues causing the discrepancy are mostly related to the system boundary, cut-off criteria, biogenic carbon treatment and allocation (Wang et al., 2018). In addition to these internationally recognised standards, numerous other initiatives have been launched by public or private organisations at regional and local level. Some of these initiatives focus only on GHG emissions, while others include other environmental impacts. The use of PAS 2050 is generally preferred in the estimation of seafood VA because it includes specific guidelines for seafood (Gabrieli & Jafarzadeh, 2020).

In determination of greenhouse gas inventories today, international standards established by the Intergovernmental Panel on Climate Change (IPCC), created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), are utilized. Through this method, carbon dioxide emissions are expressed as the product of sectoral emission factors and the total fuel consumption attributed to human activities. In carbon footprint calculations, lifecycle assessment is crucial. Various intervals can be selected for evaluation

3.3. Carbon Footprint Studies in Fisheries

In the literature, there are carbon footprint determinations for small-scale fisheries (Ferrer et al., 2022), for trawl fisheries (Sala et al., 2022), by species (Sandison et al., 2014) and by country (Iribarren et al., 2010). Tyedmers et al. (2005) estimated that globally, marine capture fisheries consumed 42.4 million tonnes of fuel in 2000, or 1.2% of global oil consumption, and emitted about 134 million tonnes of carbon dioxide (CO_2) into the atmosphere.

In a study conducted in 2011, fishing vessels produced 179 million tons of CO_2 equivalent greenhouse gases in response to 40 billion liters of fuel consumption, which accounts for 4% of food production.

The emissions per kilogram of landed fish increased by 28% from 1990 to 2011, reaching 2.2 kg CO_2-eq/kg (Parker et al., 2018). In another study conducted in 2016, this value was 207 million tons of CO_2 equivalent greenhouse gases (Great et al., 2018). When we look at the difference between 2011-2016, we see a positive value of 28.6 million tons of CO_2 equivalent.

3.4. Turkish Fisheries and its Status in Carbon Footprinting

In Türkiye, which has a coastline of 8,333 km, 83% (15,291 vessels) of the fishing fleet (18,476 vessels) operate at sea. The majority of these vessels (89%-13,670 vessels) are small-scale fishing vessels with a length of less than 12 metres and generally made of wood, using fishing gears such as extension nets, longlines, coastal drift gears, algarna and traps. 1,621 vessels are large-scale fishing vessels of 12 m and larger length, usually made of sheet metal, using trawl or purse seine fishing gears (Table 2) (GDFA, 2022).

Table 2. Number of vessels in the Turkish fishing fleet by size groups and seas (GDFA, 2022)

Groups	Mediterranean	Agean Sea	Marmara and Bosphorus	Black Sea	Total
<12 m	1,446	3,533	3,292	5,399	13,670
12-23.9 m	231	147	413	328	1,119
>24 m	36	24	271	171	502
Total	1,713	3,704	3,976	5,898	15,291

Fishing of fish and other aquatic organisms, which has an important place in food supply security, is carried out by small and large-scale fishing fleets in Türkiye as in the whole world and carbon emission (emission) is realised during these activities.

In Türkiye, a study (Dağtekin et al., 2022) has been conducted only for anchovy fisheries in the Black Sea.Due to the international trade sanctions mentioned above, it is considered that there is an urgent need to determine the carbon footprint of the Turkish fishing fleet in a way that covers all seas and deals with small and large-scale fisheries separately.

4. Recommendation

Especially considering that oceans and seas are the largest source of oxygen, carbon sinks obtained from aquatic resources are the most important emission reducing environments.

-It is of great importance that these environments are not affected by acidification.

-Acidification, which manifests itself as warming of the waters, deterioration of the ecosystem, increase in invasive and alien species and decrease in stocks, can be combatted by increasing decarbonization activities.

-Action plans should be made for all these activities and legal regulations and certification systems for carbon emission in fisheries (fishing and aquaculture) should be implemented in international standards.

-The fisheries authority should already take steps that will set an example for decarbonization efforts, and support elements such as limiting the power of machinery, encouraging the use of electric motors, and making use of solar energy.

-The carbon footprint of Turkish fisheries should be defined/calculated for all types of fisheries as soon as possible. There is no integrated carbon emission study of the fishing sector in Türkiye. Blue Carbon and Carbon Sink Areas are no longer concepts.

As a result, Türkiye should start to identify, monitor and report greenhouse gases in the fisheries sector as soon as possible in its efforts towards the 2050 emission target.

Ethical approval

The author declares that this study complies with research and publication ethics.

Informed consent

Not available.

Conflicts of interest

There is no conflict of interests for publishing of this study.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Author contribution

Both authors contributed equally to this work. Contributions include Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing-original draft, Review and editing.

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Lead-210 concentration in Sea Urchins *(Paracentrotus lividus)* and Patella *(Patella vulgata)* Species in İzmir-Urla Bay, Türkiye

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Abstract

Patella (*Patella vulgata*) and sea urchin (*Paracentrotus lividus*) species were collected in each season (winter, spring, summer, autumn) and analyzed for lead-210 levels in soft tissues. In the literature, there is no data for ^{210}Pb activity concentrations for patella (*Patella vulgata*) and sea urchin (*Paracentrotus lividus*) species on the Turkish coast of Aegean Sea. In general, the highest ^{210}Pb concentrations were measured in spring and winter for both species. Limpets are promising bioindicators, showing sensitivity to pollutants and accumulating them in their tissues. This study shows the potential of sea urchins as bioindicators for monitoring the impact of industrial activities on marine ecosystems.

Keywords: Patella (*Patella vulgata*), sea urchin (*Paracentrotus lividus*), ^{210}Pb.

Effects of Microplastics on Aquatic Organisms

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Abstract

Microplastics have become a global problem due to increasing pollution. Microplastics are petroleum-derived polymeric particles smaller than 5 mm, uniformly shaped or amorphous, insoluble in water. The amount of microplastics inevitably increases as large, single pieces of plastic break down and eventually break into millions of microplastic fragments. Microplastics are also found in aquatic environments. Since they first appeared in ocean and marine organisms, global concern about microplastics has increased significantly. A large proportion of plastic pollution in marine environments originates from terrestrial environments. Plastics entering the aquatic environment through rivers and domestic wastes as a result of human activities harm humans through various living organisms. They are found in the bodies of many aquatic organisms such as plankton, crustaceans and fish. They harm organisms at the top of the food chain. They usually become harmful to human health through fish consumption. This study investigates the potential effects of microplastics on aquatic organisms.

Keywords: Aquatic organisms, environment, microplastics

Seaweed Aquaculture for Food Security and Environmental Health

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Abstract

In this study, the benefits of Seaweed Aquaculture at national and international levels were summarized. According to the World Bank Technical Report (2016), producing large amount of seaweed biomass and seaweed protein for the increasing human population with no new land and freshwater expropriation for agriculture would dramatically reduce humanity's ecological footprint relative to current trends and projections in the area of food security, energy security and environmental health.

Türkiye has potential 289,018.5 tonnes. y $^{-1}$ Carbon sequestration just by potential seaweed production of 963,395 dry weight seaweed annually, if the country increased its production to match production in China which produces ~116 tons dry seaweed y $^{-1}$ km $^{-1}$.

Türkiye has a total of 24.6 million ha coastal zone, of which 1.5 million ha area approximately 15,000 km^2 called "economic coastal zone", has a high potential to grow seaweed species. According to the World Bank Technical Report, Turkey can cultivate 15 million tonnes seaweeds in the area that the country has. From this amount of seaweeds, the country can produce 1.5 million tonnes of protein and 450,000 tonnes seaweed oil. And, that much production can remove 300,000 tonnes of nitrogen, 3,000 tonnes of phosphorus, capture 5,550,000 tonnes of CO_2 supply 37,500,000 MWH bioenergy, and it saves cropland area approximately 3,000 km ^{2} with 15 km ^{3} freshwater.

Keywords: Seaweeds, Aquaculture, IMTA, Food security, Environmental Health

Introduction

Seaweeds, micro-algea and macro-algea are the three type of algae. They constitute the primary pruducers in the aquatic food chain consequently its have an important place in aqua system. Algae is the source of life of the aqua system in terms of food production and sustainable food chain. In addition algae has a big role for producing a hundred million tons per year of marine fisheries and a large portion of the aquaculture production, a stable human food supply. Among the seaweeds, 13% have been using for the production of hydrocolloids (polysaccharides), such as agar, alginate or alginic acid and carrageenan while 75% are used for food and the remaining (12%) are used by agriculture industry [36]. According to statistical annual reports, seaweed were produced both from nature and aquaculture farms and it was 32.4 million tons in 2018. In addition 96% of seaweeds were produced by aquaculture with the value of 12.6 billion US dollar in 2018 [26]. Japan consumed forty percent of the seaweed production in 2020 and this data represents this country is traditionally user around of the world datas. Moreover, 8.8 million of tons of Kombu (*Saccharina japonica*), 2.7 million tons of Wakame (*Undaria pinnatifida*) and 2.1 million tons of Nori (*Porphyra* sp.) which is particularly used dried in sushi preparation were produced according to 2014 reports[26].

The traditional using of sea vegetables as an auxiliary food in culinary culture have been a history of several centuries in Pacific and Asian countries [47]. In a variety of dishes such as raw salads, soups, cookies, meals and condiments have long been preparing by seaweed in Pacific such as Philippines, Indonesia, Maori of New Zealand, Hawaii and Asian countries such as Korea, China, Japan [47, 85]. In the other hand based on traditional seaweed-food consumption have been existing in France, Iceland, Wales, as well as the Canadian and U.S. Maritimes and varies in importance depending between country and regions but which is overall less prominent than in Asia [15, 85].

Recently, the food industry were developed as a new area by the plant protein concentrats production (PCs) [69]. PCs were extracted from three edible green seaweed species of *Enteromorpha,* or *Ulva* and were investigated for their functional properties as functions of salt and pH [40]. The protein contents range in the PCs are observed as a variety from around 33 to 60% [58]. The minimum nitrogen solubility was observed at pH 4 in all three PCs and foaming capacity and stability were pH-specific [58]. There are important points although these results are promising well. Food grade solvents have to be chosen during the extraction method avoiding chemical residues, which could be toxic before considering these PCs as ingredients in food formulations [58]. As a result, in terms of human consuption solvent choice influences potential applications of algal protein extracts [63].

The dynamics that are wave exposition, seaweed species, harvest location and time, and water temperature varies seaweeds, including *Ulva* species, main constituents. In addition the large variations are sometimes observed consequently the methodology used to determine these constituents may differ which may explain why. The concentration up to 76% of the dry weight was reported and seaweeds are rich source of carbohydrates [58, 59]. Important proportion of proteins were quantified [24]. Also *Ulva* species in general contains up to 44% of proteins based on the dry weight. The mineral content also were found for *Ulva* sp. reaches values as high as 55% [61]. Independently of the species, generally seaweed lipid content is relatively low (<5%) [23, 53, 56, 58, 62, 70]

Seaweeds are well known for their abundance in several nutrients as dietary fibers, minerals (ie, iodine) and certain vitamins (ie, B12) and also contain numerous proteins/peptides, polyphenols and polyunsaturated fatty acids (omega-3) [11]. Seaweeds contain certain vitamins (ie, B12) also contain numerous proteins/peptides, polyphenols and polyunsaturated fatty acids (omega-3). In addition these are well known for their abundance in several nutrients as dietary fibers, minerals (ie, iodine) [11]. There are several potential health benefits of seaweeds have been reported, including cardioprotective, neuroprotective and anti-inflammatory effects as well as beneficial impacts on gut function and microbiota and also a diet rich in seaweed in Asian countries has been consistently associated with a low incidence of cancers [19, 44]. These results strongly support the use of seaweeds in functional food development and also to promote new utilization in food products and in the consumer's kitchen.

The increasing of vegetable consumption, including seaweeds, has been promoted to exert health benefits during Inuit childhood and life-course [33, 39]. Herewith, it is possible to see many cooking books incorporating recipes using "SEA VEGETABLES" in many countries around the world. Consequently more recently there has been a strong movement in European countries to introduce sea plants into the European cuisine. Marine plants receive an increasing acceptance with the current trent for consumers, as "natural" food sources. [13, 47].

Recent popularity of sushi has stimulated the seaweed economy in Western countries, including Turkey and Asian cuisine. As the Asian population spreads to different countries of the world, new ingredients from seaweed were discovered and inspired food chefs in restaurants to create new flavors. *Ulva, Laminaria* and *Porphyra* [1] are well known species addition to the other species as among the seaweeds traditionally consumed by Asian population used in Asian cuisine. While some species can be eaten raw such as Nori and sea lettuce, *Ulva* Species such as Wakame or Kombu requires cooking to overcome their chewy texture [50]. The valorization of seaweed as sea vegetables generally involves salting or drying processing treatments. Seaweed drying is one of the primary step to allow their storage and transportation. They are either sun dried, air dried or dehydrated by salt addition [29, 30, 32, 80]. And also Seaweed can be macerated with specific enzymes to improve protein bioaccessibility through hydrolysis of dietary fibers resistant to human digestion but this process hasn't reach any commercial application yet [27, 28, 30, 31]. However, there are some recent studies on *Ulva lactuca* that is fermented with specific enzymses to improve protein bioaccesibility resistant to fish digestion [67]. The growth of lactic acid bacteria was dependent of the seaweed species in during fermentation process, presence of fermentable carbohydrates such as laminaran and heating treatment applied prior to the inoculation step [35]. All these processing treatments are likely to affect seaweed's nutrients but there is a limited number of studies describing their impact to our knowledge. Useful information to promote their usage in innovative dish and food preparation can be provided by more researches.

A green seaweed sea lettuce or *Ulva* used where it is added to soups or used in salads in Scothland [38] and it is used in making sushi also with a red seaweed Nori or *Porphyra* today in Japan [47]. In the formulation of innovative seaweed dishes and food preparation samples, traditional mezze recipes belong to some vegetables replaced with *Ulva* (freshly harvested with 22.42% protein, dry weight) in Turkey [73]. The *Ulva* dishes were prepared according to traditional recipes of stuffed grape leaves, spinach with rice, lamb's lettuce salad, salicornia mezze, spicy tartare meatballs, and fresh sardines in grape leaves [3, 51, 71].

The development of sustainable seaweed cultivation for a variety of profitable end-products, such as phycocolloids, vitamins, protein, minarels, pigments, etc are encouraged by all these advantages together with available modern technologies and the proximity of European and Asian market. Algae cultivation is limited to micro-algae production in fish hatcheries in Turkey. On the other hand, natural resources are abundant for necesarry commercial seaweed cultivation, such as diversity of seaweed species, clean water, sunlight, coastlines are abundant. For instance; Seaweed species that is have been identified more than 1000 and species of *Porphyra, Gracilaria,* Juvenil *Laminaria, Cystoseira, Sargassum,* and *Ulva is* being especially abundant in Turkey [20]. The consumption of algae as a food is mostly limited to traditional algal cuisine from Asia in the overall Turkish population [41, 73]. However, *Ulva* breads [73] and the traditional Turkish foods such as Stuffed *Ulva, Ulva* with rice, *Ulva* salad, Sea lettuce *Ulva* mezze, Spicy tartare meatballs with *Ulva*s, and Fresh sardines in *Ulva* can be prepared with green lettuce or green seaweed *Ulva* [71, 73].

In this paper, seaweeds'contiribution on food security as a human food and animal feed, including aquafeeds and environmental health, including their biofiltration or bioremediation capacity, wastewater treatment with seaweeds, including fish effluent treatment, and growing seaweeds against global warming and climite change is underlied.

Seaweed Aquaculture for Food Security and Environmental Health

To maintain current food consumption trends the world needs to produce 50–70% more food by 2050. And, depending on bioenergy policies, the biomass use will continue to rise by following years [4, 6, 72].

Producing large volumes of seaweeds for human food and animal feed could represent a transformational change in the worldwide food security equation [6]. The worldwide production of seaweeds was approximately 3 million tons dry weight in 2012 and it have been growing by 9% per annum. Increasing the growth of seaweed farming up to 14% per year would generate 500 million tons dry weight till 2050 and adding about 10% to the world's present supply of food and also it has been generating revenues and improving environmental quality (Table 1) [6].

Table 1. Extrapolated ecosystem services from 500 million mt (dry weight) of seaweeds [6].

Ocean area required	500,000 km^2	Based on average annual yield of 1,000 dry tons per km^2 under the current best practice. Equals 0.03% of the ocean surface area
Protein for people and animals	50,000,000 mt	Assumes average protein content of 10% dry weight. Estimated value USD 28 billion. Could completely replace fishmeal in animal feeds.
Algal oil for people and animals	15,000,000 mt	Average lipid content is assumed as of 3% dry weight. The value that estimated is USD 23 billion. It could completely replace fish oil in animal feeds.
Removal of Nitrogen	10,000,000 mt	Nitrogen content is assumed as 2% of dry weight and equals 18% of the nitrogen into oceans through fertilizer.
Removal of Phosphorous	1,000,000 mt	Phosphorous content was assumed as 0.2% of dry weight. It represents 61% of the phosphorous input as fertilizer.
Assimilation of Carbon	135,000,000 mt	Carbon content is assumed as 27% of dry weight. It equals 6% of the carbon added annually to oceans from greenhouse gas emissions.
Potential of Bioenergy	1,250,000,000 MWH	Carbohydrate content which converted to energy is assumed as 50% and it equals 1% of annual global energy use.
Sparing of Land	1,000,000 km^2	Average farm yield is assumed as 5 tons per ha area. It equals 6% of global cropland.
Sparing of Freshwater	500 km^3	Agricultural using averages are assumed as 1 m^3 water per kg biomass. It equals 14% of annual global freshwater withdrawals.

Seaweed based- IMTA (Integrated Multi-Trophic Aquaculture) system has enormous potential for growth in Turkey where there are direct groundworks toward the development of IMTA and active research programs gaining knowledge about their regions potential for development of IMTA [72] . The country has a total of 24.6 million ha coastal zone, of which 1.5 million ha area, called "economic coastal zone", has a high potential to grow seaweed in ecologically-balanced IMTA systems. Turkey is still in its infancy and its potential in mariculture is far from being fully exploited. From the point of seaweed including *Ulva* aquaculture, Turkey is just using its marine aquaculture potential at minor levels. However it is believed that it will expand undoubtedly in following years by seaweed cultivation in IMTA systems where with 15% dry weight content, 5 ton fresh weight seaweed per hectare per year in sea-based IMTA and 110 ton fresh weight seaweed per hectatre per year in land-based IMTA systems can be cultivated [72]. And, producing a ton of dry algal biomass at IMTA system utilizes approximately 360 kg carbon, 63 kg nitrogen and 8.6 kg phosphorus. 830 tons of CO_2 can be taken up annually by a 1,000 mt fish-2,000 mt shellfish-500 mt seaweed IMTA farm and 1,230 tons of CO_2 can be taken up annually by a 1,000 mt fish-7,000 mt seaweed IMTA farm. Turkey has potential 289,018.5 tonnes per year. Carbon sequestration just by potential seaweed production of 963,395 dw seaweed annually, if the country increased its production to match production in China which produces ~116 tons dry seaweed per year per km coastline [72].

Seaweed Farming Systems

The main parts of seaweed production system includes inducing seaweed individuals to release spores, sporophyte/gametophyte attachment and seaweed nursery rearing, Seaweed grow-out in tanks, raceways, ponds freely un-attached forms or grow-out on long lines at off-shore or in tanks, raceways and ponds on-shore or on-land systems, including IMTA (Integrated Multi-Trophic Aquaculture) systems and, harvesting steps.

Obtaining Seaweed Spores and Nursery Steps

In the nursery, Seaweeds are induced to release spores through light and temperature manipulation. The spores settle at the bottom of nursery units (tanks, aquariums, or glass) or on seedling ropes coiled into some materials suspended in the nursery units.

When the mature seaweed has released, the sporophytes/gametophytes attach to the bottom of the nursery units for grow-out tank, raceway, pond cultivation for un-attached seaweed forms or attach to seedling ropes for grow-out systems for attached seaweed forms. Attached or un-attached seedlings remain in the nursery units for almost a month until a sporophyte/gametophyte reach the length of 1 mm. The average time between batches is 30 days. Light for photosynthesis comes from lamps (120 cm, 36 watt, neon) situated on top of each nursery units. The light is used for 17 hours during the day. As a culture medium, Guillard’s F/2 medium can be used [68].

Grow-Out and Harvest Steps

Unattached or attached seaweed seedlings can be grown in different structures at land-based or on-shore or off-shore aquaculture systems, including IMTA (Integrated Multi-Trophic Aquaculture) systems.

IMTA can be applied to on-land and off-shore aquaculture systems and IMTA is an innovative solution being proposed for environmental sustainability, economic diversification, and social acceptability [72]. This practice combines seaweed species and the cultivation of finfish with shellfish for an ecologically-balanced aquaculture management approach. As the wastes of the main cultured species are biomitigated through conversion into fertilizer, food, and energy for additional commercially valuable species IMTA increases the long-term sustainability and profitability per cultivation unit. Costly waste mitigation processes become revenue-generating cultivation components, which by their harvest export nutrients outside of the coastal ecosystem in this way [71].

In fact IMTA is not a new concept. For instance; Asian countries have been practising the precursor of IMTA for centuries as polyculture which produces a large fraction of the world's freshwater fish [25]. In recognition of growing interest, The Aquaculture Europe 2003 Conference was was the first large international meeting with IMTA as its main topic in Trondheim, Norway whose theme was 'Beyond Monoculture'. IMTA was recognized as an emerging research priority and alternative to consider for the future development of aquaculture practices at the joint European Aquaculture Society and World Aquaculture Society Conference in Florence, Italy In 2006. The determination to develop IMTA systems will need some visionary changes in political, social and economic reasoning. A regulatory internalization of the total environmental cost of the aquaculture operation and enforcement of the polluter pays principle will improve and protect the sustainability, long-term profitability and responsible management of coastal waters will be accomplished [14].

IMTA has been already developed and practiced semi commercially and commercially in several places in the world, such as in South Africa, Canada, Israel, Chile, and China [7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 75, 76, 77, 81, 84]. It has demonstrated that land-based and off-shore IMTA systems are technically feasible and economically profitable. In addition, many pioneer studies have been conducted in the United States of America, Spain, Portugal, France, United Kingdom of Great Britain, Ireland, Norway, Sweden, Finland [2] and Turkey [21, 52,74].

Seaweed seedlings from the nursery room can be cultured in PVC tanks [73] and concreate ponds filled with fish (*Mugil cephalus*) effluent. Seaweed reduces the nutrient (Nitrate and phosphate) content of the fish effuent by up to 50% and they increase biomass weight by about 15 % per day (150 $g.m^{-2}.day^{-1}$ fresh biomass yield) in spring and 20% per day (200 $g.m^{-2}.day^{-1}$ fresh biomass yield) in summer times. In these type of systems, seaweed biomass can be harvested weekly and fresh or wet seaweed biomass with high protein levels (25% of its dry weight) can be used in feeding trials of marine ornemental fish species, sea urchins, sea cucumber or dry biomass can be prepared in the formulation of human food and animal feeds, including aquafeeds.

Seaweed seedlings can be cultivated in different structures by using PVC nets at land-locked lagoon or open sea areas. In these types of systems, seaweed biomass can increase its biomass weight by about 10 % per day (100 $g.m^{-2}.day^{-1}$ fresh biomass yield) in summer time and the biomass with 20% protein level can be used for human and animal consumptions.

Seaweed can cultivated in seedling lines placed in different structures such as bamboos and robes at on-shore or off-shore systems. For these type of grow-out systems seaweed grow-out modules can be prepared at different sizes depends on the farm size.

After 6-8 weeks, harvesting can begin for seaweed species at favorible environmental conditions. Some species are harvested in their entirety and new seedling lines installed; others are trimmed every 10–15 days and allowed to regrow throughout the growing season.

Conclusions and Recommendations

The expansion of seaweed growing could have big positive impacts on local poverty, ecosystem management and climate change mitigation. Being able to produce large amount of seaweed biomass and seaweed protein for the increasing human population with no new land and freshwater expropriation for agriculture would dramatically reduce humanity's ecological footprint relative to current trends and projections in the area of food securty, energy security and environmental health.

Large amount of seaweed production at Integrated Multi-Trophic Aquaculture (IMTA) systems is possible. Presently, the most common IMTA systems in open marine waters have three components (fish, suspension feeders such as shellfish, and seaweeds in cages and rafts), but they are more simple systems now. More advanced IMTA systems have several other components, such as crustaceans, sea cucumbers, sea urchins, polychaetes etc. [72].

Turkey is still in its infancy and its potential in mariculture is far from being fully exploited. From the point of seaweed aquaculture, Turkey is just using its marine aquaculture potential at minor levels, however it is believed that it will expand undoubtedly in following years by seaweed cultivation in IMTA systems where with 15% dry weight content, 5 ton fresh weight seaweed/ha/year in sea-based IMTA and 110 ton fresh weight seaweed/ha/year in land-based IMTA systems can be cultivated. And, producing a ton of dry seaweed biomass at IMTA system utilizes approximately 360 kg carbon, 63 kg nitrogen and 8.6 kg phosphorus and 830 tons of CO_2 can be taken up annually by a 1,000 mt fish-2,000 mt shellfish-500 mt seaweed IMTA farm and 1,230 tons of CO_2 can be taken up annually by a 1,000 mt fish-7,000 mt seaweed IMTA farm. Turkey has potential 289,018.5 tonnes. y^{-1} Carbon sequestration just by potential seaweed production of 963,395 dw seaweed annually, if the country increased its production to match production in China which produces ~116 tons dry seaweed y^{-1} km^{-1} [72].

Turkey has a total of 24.6 million ha coastal zone, of which 1.5 million ha area, approximatelly 15,000 km^2 called "economic coastal zone", has a high potential to grow seaweeds. According to the data summarized in Table 1 and given as the World Bank Technical Report [6] , Turkey can cultivate 15 million tonnes seaweeds in the are that the country has. From this amount of seaweeds, the country can produce 1.5 million tonnes of protein and 450,000 tonnes seaweed oil. And, that much production can remove 300,000 tonnes of nitrogen, 3,000 tonnes of phosphorus, capture 5,550,000 tonnes of CO_2, supply 37,500,000 MWH bioenergy, and it saves cropland area approximatelly 3,000 km^2 with 15 km^3 freshwater.

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Effect of Vermicompost supplement on Rainbow trout performance

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Abstract

Rainbow trout is a valuable fish in aquaculture and it has an important role in human nutrition and the economy of countries. Vermicompost is the product of organic waste digestion by earthworms besides with aerobic decomposition at ambient temperature. It is a rich composition containing plant nutrients and beneficial microorganisms. Some fishes, especially carnivorous species such as rainbow trout, need an expensive food, and replacing it with useful and cheap food such as vermicompost can be important aim of aquaculture research. In this study, the effect of using different percentages of vermicompost in the diet of rainbow trout was investigated. For this purpose, 100 rainbow trout with an average weight 120 gr were distributed in 5 groups in concrete tanks. Their nutrition and physical and chemical water parameters were provided according to the standard. Vermicompost with confirmable and relevant analysis was added to their daily feed (0 as control, 2, 4, 6, and 10%). After 2 months, the food conversion ratio and survival rate of fish were examined. The results showed that, there is a significant relationship between performance of control group and the treatments groups (p<o.o5). The data obtained from this experiment indicated that the 10% of vermicompost in diet was more effective. The study indicated that use of vermicompost supplement is promising feed additive and can be recommended in culturing of rainbow trout.

Keywords: Rainbow trout, Vermicompost, performance

Monitoring the studies on feed selection for raising young trout in a commercial trout farm.

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Abstract

This study was conducted in a private trout farm. The farm managemet wants to decide which of the three different feed it plans to buy to use in fry breeding, which feed of the same size will be purchased. The study was conducted in two replications by placing 10,000 young trout with an average weight of 5 g in 6 ponds allocated for this purpose. The study was planned for 6 weeks and was conducted at 13±0.5ºC. The growth parameters of the fish were taken from the fish sampled weekly and it was determined which feed provided better growth.

Keywords: Trout farming, FCR, feed quality

A Sustainable Aquaculture Technique: Aquaponics and Future Focus

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Abstract

Industrialization, climate change, increased water pollution and decrease in agricultural areas will pose serious problems in the coming years. These make sustainable food production «using less energy» and «using less water» important. One of the most ideal solutions to resource problems is Aquaponic Systems. Aquaponic systems ensure the sustainable use of water in aquaculture and plant agriculture in cycles. Thus, fish and plant production are carried out together in the same system. It is a system model that does not harm the environment because it provides an economical production but is produced with natural resources. This system is being implemented in a modern way in many countries and in Türkiye in recent years with the help of developing technology. In this study, it is explained that economical and sustainable fish and plant production is carried out using a small amount of water. Dissemination of this technology is crucial and, also more useful and sustainable techniques should be focused for future. Implementing a sustainable system and setting standards is indispensable for future generations and the future of our world.

Keywords: Aquaponics, dissemination, education, environment, sustainablity

Introduction

The water is one of the indispensable natural resources and increasing sensitivity in the protection of water resources is also reflected in the environmental policies of governments. The issue of protecting water resources, which is of strategic importance for the environment, health, nutrition and energy economies, is on the agenda more than ever in our country and in the World.

Sustainability refers to the ability of a society, an ecosystem, or an ongoing system to continue to function for generations to come without depleting its essential resources (Austin at al., 2023). Aquaponic systems are important systems in sustainable agricultural and animal production, as they are closed circuit, suitable for intensive production, suitable for vertical farming in urban areas, and environmentally friendly production with minimum waste (Rakocy et al., 2012, Silva et al., 2017).

Aquaponic systems are fish and plant production models obtained by combining aquaculture and hydroponic systems. Aquaculture is the cultivation and production of fish and other aquatic species (animals and plants) under controlled conditions. Hydroponic systems are defined as production systems in which plant production is carried out using water, without soil (Bodur and Okudur, 2017, Can and Seyhaneyildiz Can, 2023).

This system has a number of purposes. These purposes include both raising fish and plants and treating fish wastewater. The community and economic development benefits of aquaponic systems are given in Table 1. (Goodman, 2011).

Table 1. Community and economic development benefits of aquaponic systems (Goodman, 2011).

ENVIRONMENTAL BENEFITS	FOOD SECURITY AND FOOD ACCESS	COMMUNITY DEVELOPMENT BENEFITS
o Reduces stress on declining aquaculture. o Reduces agricultural pollution and fish mortality. o Prevents problems caused by open ocean fish farms. o Reduces water requirements for agricultural production and aquaculture. o Local production reduces transportation problems	Provides fresh, local products in areas with: o Low water availability o Limited arable land Contaminated land Poor soil quality o Overfishing/fisheries collapse o Poor road access	o Teaching tool for the community Integrates into school curriculum o Teaches ecological literacy o Provides job skills training opportunities o Provides employment

Aquaponic production is one of the systems that can contribute to global food security and is generally defined as a sustainable food production method due to its reduced environmental impacts and environmental practices (Kloas et al., 2015). The main purpose of aquaponics systems is to reduce or completely eliminate the pollution load of water used in aquaculture. The water used in fish farming is very rich in nutritional elements. By giving this water to hydroponic systems, plants benefit from nutritional elements. Water is filtered by plants and the plants act as the purification unit of the cultivation unit. The pollution load of water purified by plants is reduced (Love et al., 2015). Aquaponics production uses water efficiently, allowing the same water to return to the fish species, first to the plants, and then to the fish. With the reuse of water in the system, efficiency increases and environmental impacts decrease (Rakocy, 2012). Because water is reused, less water is withdrawn from the surface or groundwater for production, so water-scarce areas can benefit from aquaponics to produce food (Rakocy, 2012; Goddek et al., 2015). Aquaponic systems can also produce food on marginal land that is not suitable for other food production systems because no soil is required. Agriculture, aquaculture and aquaponics are complex technological processes that require knowledge about ecological processes (Bakhsh, 2015; Tokunaga, 2015).

How Does This System Work?

Fish produce ammonia-rich waste by eating food. Excessive waste material is toxic to fish. Bacteria that reproduce and develop in fish tanks convert the ammonia formed into nitrite and then into nitrate. While the waste produced by fish becomes food for plants, plants absorb these nutrients in the water with their roots, removing nitrogenous compounds from the water and cleaning the water in fish tanks, making it ready for reuse. Thus, economical and sustainable fish and plant production is achieved using a small amount of water. (Love et al., 2015, Kargın & Bilgüven, 2018).

Advantages of Aquaponic System

• Aquaponic system can produce a large amount of aquatic organisms and plants with little space and little water.
• Since vegetables are grown in water, there is no irrigation process as in soil farming.
• Vegetables produced in the aquaponic system are healthier, larger (!generally not larger) and of better quality.
• There is no need for external fertilizers in the aquaponic system.
• Chemical drugs are not used.
• The level of control over production is high.
• Since vegetables are grown in water in the aquaponic system, the soil is not treated, so the risk of disease is very low and there is no use of drugs in these systems.
• Aquaponic system is a sustainable production method for urban agriculture.
• It can be applied in regions with infertile soil or unsuitable for agriculture.
• It is an environmentally friendly production model due to its low waste level.
• Daily maintenance and harvesting processes are easy and applicable.
• Lettuce produced in the aquaponic system is harvested in 35-40 days, while lettuce produced in soil farming is harvested in 50-60 days
• Since vegetable production can be done with the Multi-Stage Aquaponics system, it provides more space for production as it can be raised with good ventilation.
• It is very difficult to provide organic product production in soil agriculture. Since the substances used in the aquaponics system are organic, the product produced with this system can also be called organic (Love et al., 2015, Bodur and Okudur, 2017, Oladimeji, et al., 2020 Okomoda et al, 2020).

Disadvantages of Aquaponic System

•Although aquaponic systems offer significant advantages, they require capital investments, energy resources and specialized personnel that may be difficult to maintain. In this context, fish and plant growth must be constantly close to maximum production rates for profitability (Rakocy et al., 2006; Datta et al., 2018).
• The initial cost of an aquaponic system is high compared to vegetable production in soil. If the products to be used are selected well, the cost is likely to be amortized.
• Management variety is less compared to aquaculture and hydroponic systems.
• If fish and plant species are not selected well, the system may not be efficient.

In order for the grower to be successful, fish, bacteria and plant production should be known well..

• The temperature of the water must be adjusted correctly for the fish and plants to live in ideal conditions.
• Aquaponic systems that are not dependent on automation may require daily maintenance.
•Aquaponic systems alone may not provide all the nutrients needs of plants (Fang et al. 2017; König et al. 2018; Pérez-Urrestarazu et al. 2019).

Aquaponic System Types

Aquaponic systems provide a symbiotic lifestyle between fish, plants and bacteria, and in areas where space and water are scarce, fish and plant cultivation can be carried out in the same environment. In general, different types of hydroponic systems are used in an integrated manner with fish growth tanks. Since aquaponic systems are versatile adaptable systems, different designs can be developed on a small or large scale.
The basic components are the aquarium and plant beds. Filtration, installation, type and amount of plant beds, water circulation, ventilation frequency vary according to the needs and type of system to be used. (Mukherjee, 2013; Datta et al., 2018; Kumar et al., 2024).
There are 5 basic methods in aquaponic systems now. These can be listed as;
• Raft System,
• Filled Medium Tanks,
• Nutrient Film Technique (NFT),
• Wick System,
• Drip System.

Table 2. Comparison of Different Cultivation Systems (FAO, 2014)

COMPARISON OF DIFFERENT CULTIVATION SYSTEMS			
A) SOIL CULTIVATION	**B) HYDROPONICS**	**C)INTENSIVE AQUACULTURE**	**D) AQUAPONICS**
• Weeds grow. • Water is needed at regular intervals and in large quantities.	•The nutrients the plant needs are prepared by human hands and are expensive because salt, chemicals and trace elements are used.	• Fish feces released into the water increases the ammonia level of the environment.	• We can grow aquatic creatures and plants by using cheap fish food.
•It is necessary to collect information about the composition of the soil, its fertilization and water needs.	• Since the food used contains very strong substances, the pH level must be kept under control by constantly measuring it with electronic devices.	• Fish in unhealthy environments are prone to disease and often require medication.	• The first months are very important in aquaponic systems. When stress is observed in fish or plants after the first months in the system, it is sufficient to make pH and ammonia measurements.
• Digging and plowing are mandatory.	•Water should be discharged periodically to remove excess nutrients and reduce the toxicity of the water to plants.	• The discharged dirty water is pumped into streams or groundwater and pollutes and destroys water resources (FAO, 2014).	
• Pesticides are used to kill harmful insects and repel them (FAO, 2014).	•Plants have a high tendency to root rot disease called Pythium (FAO, 2014).		

Raft System

In this system, also known as the floating system, plants are grown on styrofoam. The plant tank is often located separately from the aquarium tanks. Water constantly flows from the fish tank to the plants and filtration system and back to the fish tank. Beneficial bacteria live in the tank containing the rafts and other parts of the system. The extra water volume in the raft tank acts as a buffer against stress and water quality problems that may occur in the fish tank. This is one of the biggest advantages of the raft system. (FAO, 2015). The raft system is a system that gives a very high yield per square meter. In a commercial system, raft tanks cover quite large areas and the greenhouse floor can be used optimally. Initially, plant saplings are placed at one end of the rafts. Mature plants growing on the rafts are pushed to one end of the tank. Thus, while new seedlings are planted at one end of the tank, mature plants are harvested at the other end (Figure 1). In this way the system repeats itself. This method is a desired feature especially for the greenhouse environment (Moderelli et al., 2023).

Figure 1. Raft System in Nihsar Aquaponic from Türkiye

Filled Media Tanks

In this system, the tank or container is filled with gravel, perlite or other fillers (Figure 2). After the plant tanks are periodically filled with water from the fish tank, the water returns to the fish tank. All wastes are decomposed by plants and beneficial bacteria in plant tanks. Sometimes decomposition is accelerated by adding worms to plant tanks. In this simple method, no additional filtration is used and the equipment used is quite minimal. However, the amount of product obtained is lower than other methods. For this reason, it is generally applied for hobby purposes (Love et al, 2015).

Figure 2. Filled Media Tanks in Nihsar Aquaponic from Türkiye

There are various filling materials in aquaponic system and some of hem are presented in Figure 3.

Pumice Stone Cockpit Hydroton

Figure 3. Filling Materials Used in Plant Roots

Nutrient Film Technique (NFT)

This method is a technique in which plants are grown in long and narrow pipe channels (Figure 4). As water moves through the channel from top to bottom, it delivers the oxygen and nutrients necessary for the plant to the roots. The water filtered by the plants moves back into the fish tank. Since there is not enough space for beneficial bacteria to live, a biological filter should also be added to the system (Engle, 2015).

NFT systems are not suitable for large volume aquaponic systems due to blockages caused by biological waste that may occur in the pipes.

Figure 4. A view of the nutrient film technique in Nihsar Aquaponic from Türkiye

Wick System

It is the system where water is absorbed and transported to the roots by an absorbent material (Gönen, 2013). These are generally preferred systems for hobby purposes.

Drip System

In this method, which is similar to the irrigation system, the plant is watered using the drip method used in traditional agriculture (Gönen, 2013).

Figure 5. Drip System in Nihsar Aquaponic from Türkiye

Fish and Plant Species Used in Aquaponic Systems

Aquatic animals produced in aquaponic systems can be for consumption or ornamental purposes. the selected species should be chosen from omnivorous or herbivorous freshwater species. The plant types to be preferred should be selected from leafy edible plants such as lettuce, mint and arugula, or vegetables such as tomatoes and peppers.
The plant and fish species most compatible with the system can be listed as follows:

Fish Used in the System
The most commonly used fish species in Aquaponics Systems is Tilapia. These are followed by Koi, Goldfish, Angelfish, Guppy, Tetra, Moli, Carp, Perch, Catfish, Blackfish and Crayfish, respectively. *Maccullochellapeeliipeelii* (Cod), *Bidyanus bidyanus* (Silver Perch), *Macquaria ambigua* (Golden Perch), *Salmo trutta fario* (Stream Fish), *Salmo salor* (Atlantic Salmon), *Perca fluviatilis* (Freshwater Perch), *Oncorhynchu smykiss* (Rainbow Trout), *Ctenopharyngodon idella* (Grass Carp), *smolitrix* (Silver carp), Koi and Tilapia (*Oreochromis sp* .) are other species used.

Plants Used in the System
The most common plant type used in this System is lettuce. Tomatoes, peppers and cucumbers are also commonly used. Additionally, Chard, Mint, Beans, Peas and Zucchini are used . Italian basil, Purple Basil, Thai Basil, Chinese Parsley (Coriander), Fenk Parsley, Italian Parsley, Chives (Garlic), Lemongrass, Mint, Dill, Watercress, Lettuce, Arugula, Wild Lettuce (Chicory), Red Lettuce , Loveflower, Calendula, Curly, Cabbage, Spinach, Far Eastern Lettuce, Chinese Cabbage, Tatsoi, Cornflower, Chinese Spinach and Flowering Cabbage.

Why Aquaponics?

The biggest problem in the studies that started on closed circuit systems in the 1970s was that nitrogenous compounds accumulated in the aquaculture environment and deteriorated the water quality. This problem has been a trigger for the beginning of Aquaponic systems and has enabled the cultivation of a second product as well as the improvement of water quality. Aquaponic systems, which enable fish and plant farming together, ensure the most effective use of water and appear as a sustainable food production system (Kizak and Kapaligoz, 2019).

In a study conducted in America, the National Restaurant Association of America examined the products used and sold by restaurants and prepared an 8-item trend list.

TRENDS (National Restaurant Association – USA)
1. Locally produced meats and seafood
2. Healthy children's meals
3. Environmental sustainability
4. Child nutrition
5. Fresh cuts of meat
6. Hyperlocal cultivation (restaurant gardens)
7. Gluten-free cuisine
8. Sustainable aquaculture.

Daily Checks to be Made in Aquaponics Systems

Although it is not difficult to ensure the continuity of the system in aquaponic systems, there are routine tasks that need to be done daily. Some of these processes are:
•Fish feeding
•Plant seeding, harvesting
•Observation and monitoring
•Water parameters control
•Cleaning of filters and systems (Food&Water Watch, 2008).

Urban Farm Examples of Aquaponic Systems

Modern developments and technologies have made food and plant production possible in all environmental conditions and ecosystems. Aquaponics has provided a positive impact on circular economies and urban agriculture systems. Positive interactions and results can be observed all year round without the use of synthetic chemicals and harmful residues. Moreover, these systems allow for greater biodiversity in cities and reduce the impact of greenhouse gases and climate changes. This system has attracted the attention of researchers and communities due to its potential to improve circular economies.

BIGH's Abattoir in Brussels
The first full-scale production on this site took place on the roof of the market in the Anderlecht district. The total area of 4000 square meters is divided into fish breeding areas and greenhouses of 2000 square

meters. These installations have significantly helped in creating natural ecosystems in urban areas and artificial environments. This farm has 14 tanks and has 60,00 stripped bass in various stages of development.

Urban Farms in South Australia

Southern Australia is of particular importance for agricultural production due to the adoption of modern technologies for drought tolerance and stress regulation. For Adelaide, the majority of food is produced near the city center area. Since aquaponic farming systems have been a major development in Australia, the system has focused on food production in closed and artificial systems. Moreover, efforts are underway to develop smaller-scale and intensive aquaponic units and urban aquaponic areas through appropriate mapping of regulatory opportunities and social barriers (Pollard et al., 2017).

Urban Farms in California and Texas USA

Aquaponic systems in the warm climates of California, USA are operated with mid-level technology but quality greenhouses to produce herbs, leafy greens and lettuce. These farms use very little supplementary heating, static shading and cooling systems. These farms raise hardy species of fish to prevent algae growth and overheating problems.

Passive Solar Greenhouses and Aquaponic Systems in Germany and the USA

These greenhouses and aquaculture systems rely solely on the use of solar energy for heating and power operations. These aquaponic systems were developed by Franz Schreier by creating a suitable environment in Southern Germany. Heat is specifically stored in underwater partial fish tanks, adobe-covered northern walls and floors to be dissipated at night. This system is also used in Vermont USA and is equipped with a steep and transparent roof towards the south to collect glass. This system has excellent insulation and the opaque north side is neatly submerged into the slopes.

Aquaponic Systems in Hixton and Wisconsin USA

This aquaponic farm has been developed for large-scale commercial farming. These aquaponic systems are supplemented with opaque, separate enclosures and automatic heating and LED lighting systems for the production of leafy greens. Moreover, there is the use of different sensors for optimization of environmental conditions.

Thanet Earth in England

It is one of the largest complex systems in the UK and is located in south-east England. This system is powered by the use of the heating and power system to provide CO_2, heat and power to the growing systems. Additionally, there is the use of computer-controlled strategies and technologies such as ventilation, supplemental lighting, and energy curtains.

Rooftop Aquaponic Systems in Europe and Switzerland

In Europe, rooftop aquaponic farms equipped with high-tech systems are used and efficient urban farming systems are provided. Ecco-jäger Aquaponik Dach farm in Bad Ragaz, Switzerland is family-owned. The Venlo style roof was built on a warehouse and a two-storey building. Additionally, there is important ongoing work for the integration of specific aquaponic technologies by the Catalan Institute of Paleontology (ICP) and the Institute of Environmental Science and Technology (BTK).

Urban Organics in Canada and the USA

Urban organics is located in Minnesota USA and St. It operates commercial-scale indoor growing aquaponics in St. Paul. These farms grow herbs and leafy greens using fluorescent grow lights and grow beds. The neutropenic system is also used to grow leafy greens in Alberta and Edmonton. This system provides excellent control over external conditions and accelerates crop production throughout the year (Proksch et al., 2019).

Turkey- Izmir Nihsar Organic Facility

Nihsar Organic Facility carries out aquaponics production 12 months of the year with its 750 m2 private greenhouse located on 8.5 decares of land in Foça Kocamehmetler village of Izmir. Along with many lettuce varieties, strawberry, brown and cherry tomatoes are among the most produced tomato varieties. Goldfish, koi and mirror carp, which are fish species that form an important part of the aquaponics system, are also produced in this facility.

Figure 6. The view of Nihsar Organic Facility, Izmir-Türkiye.

Discussion

Aquaponic systems are the perfect combination of aquaculture and plant agriculture. In this system, fish waste becomes a source of biological fertilizer for plants, while plant roots serve as a natural filter for fishponds. It is more advantageous compared to hydroponic and aeroponic systems, which are soilless plant growing methods. In these systems, artificial and expensive substances consisting of a mixture of nutritional salts and trace elements are used to ensure that the water in the pool provides sufficient food for the plant roots. Only fish food is used in the aquaponics system. Thus, a more economical production is achieved. Additionally, there is no need to change the water used in the aquaponic system. Addition is made only by calculating the amount of evaporated water. 1/10 of the water used in traditional agricultural production is used. It can be easily applied even on lands that are not suitable for agriculture, so that the agricultural lands that are decreasing day by day can be used more effectively and efficiently. This system has advantages as well as negative aspects. Investment cost is high.. The energy cost required for the operation of the equipment can be high. In addition, the life of plants and fish may be endangered as a result of any problems that may occur in the equipment. The personnel must be competent and knowledgeable and keep the system in appropriate conditions (pH and EC values).
This developing system is advancing rapidly in terms of sustainability. It is anticipated that high efficiency will be obtained from the system planned with good equipment and correct information.

Conclusion and Future Focus

Why don't we grow both our own fish and our own vegetables on our gardens by ourselves? Like a hen, duck, lamb etc? What do you think an education program for schools where they use aquaponic farming systems for our youth? Will we expand this by spreading it all over the world?
Dissemination of this production method should be enlarged to worldwide to achieve sustainable use of water. Mobile aquaponic vehicles can be useful tools for the dissemination of this production technology all over the World by the universities and other governmental bodies etc. And also, artificial intelligence can be used to achieve this aim.
The farmers are required to have education *It is anticipated that high efficiency will be obtained from the system planned with good equipment and correct information.
Have you ever tested fish and vegetable produced with aquaponics technology. We can say that really very delicious so the studies should be focused on biochemical test parameters and the governments should also give a full support about in both producing and consuming.
Besides, we know that there are 5 basic methods in aquaponic systems up to now however, more useful and sustainable techniques should be focused on for sustainable future. Although the idea of sustainability is simple, its implementation is challenging in today's conditions due to economic reasons and various conflicts of interest. However, implementing a sustainable system and setting standards is very important for future generations and the future of our world.

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Determination of Minimum Inhibition Concentration of *Aeromonas hydrophyla* Bacteria by Using *Moringa oleifera* Ethanolic Extract

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Abstract

In this study, the effects of ethanolic extracts of *Moringa oleifera*, a plant of the Moringaceae family, on stopping *Aeromonas hydrophila* bacteria causing diseases and deaths in fish were investigated in vitro. The microdilution method, one of the Minimum Inhibition Concentration tests, was used in the study. As a result of the study, it was aimed to stop the production of *Aeromonas hydrophila* bacteria on their *Moringa oleifera* ethanolic extracts of certain concentrations. At the same time, this work also plays an important role in light handling in future in vivo studies. For this purpose, firstly the ethanolic extract of *Moringa oleifera* was removed by evaporator. Then, bacteria were prepared for the microdilution method. Worked on 96-well plates and 150 µl strains per plate respectively at the concentrations of 256 ppm, 128 ppm, 64 ppm, 32 ppm, 16 ppm, 8 ppm, 4 ppm and 2 ppm. 3 µl of each well was added to the prepared wells. In addition, only the medium (agar) and 3 µl of the bacteria were added for the viability test of the bacteria in different wells (positive control) and only a mixture of nutrient and methanolic extract was added to see if the medium was contaminating during work (negative control). Each bacterium and all concentrations were studied in duplicate. The present study showed that *Aeromonas hydrophila* has been shown proliferation at a concentration of 64 ppm of the *Moringa oleifera* ethanolic extract.

Keywords: *Aeromanas hydrophila,* MIC test, *Moringa oleirefa*

Introduction

Aquaculture products are an important food source with high protein value and essential for a healthy and balanced diet. It constitutes 17% of the animal protein consumed worldwide and 6.5% of all protein sources. With the growth of the industry and the increase in production, infectious diseases that cause significant economic losses have emerged due to some factors in culture conditions (density, manual intervention, sudden changes in temperature, poor water and conditions, stress and suppression of immunity) (Naylor et al., 2000; Cabello, 2006; Maqsood et al., 2011; Reverter et al., 2014).

Microorganisms such as bacteria, fungi, viruses and parasites are the agents of many infectious diseases and antimicrobial compounds are used against these microorganisms. The use of these compounds has been restricted due to their numerous side effects on health and environmental safety. With the intensive use of antibiotics in the treatment of bacterial diseases, residues can form in fish tissues and as a result, the development of antibiotic-resistant pathogens increases. In addition, antibiotics accumulate in fish and pose a potential risk to both environmental health and consumers (Zheng et al., 2009; Harikrishnan et al., 2010; Okmen et al., 2012). For all these reasons, today, alternative searches have been made for disease prevention.

It has been reported that medicinal plants and essential oils, ethanolic or methanolic extracts obtained from them have antibacterial, antiviral, antifungal, anti-inflammatory, antiseptic, antioxidant, antiparasitic, antitoxigenic and insecticidal properties and that they are also effective on microorganisms that have gained resistance to antibiotics (Yiğitarslan et al., 2011; Bayaz, 2014; Görmez & Diler, 2017; Salem et al., 2021).

Moringa oleifera (common name = moringa, drumstick tree, or Miracle tree) is a fast growing plant widely available in the tropics and subtropics and has several economically important industrial and medicinal uses (Richter et al., 2003). Thus, the leaves, fruits, bark, and roots have high nutritive value and possess medicinal properties, such as antitumor, anti-inflammatory, antiulcer, antihypertensive, cholesterol-lowering, antioxidant, antidiabetic, hepato-protective, antibacterial, and antifungal activities. M. oleifera seeds contain 36.7% fat, 31.4% protein, 18.4% carbohydrate and 7.3% fiber. It is recommended to add oiled M. oleifera seeds to supplementary foods as a protein source. It has been reported that the seeds of the plant are equal to milk and eggs in terms of methionine and cysteine content. The ethanol seed extract was also found to carry some bioactive compounds such as benzyl carbamate, benzyl isothiocyanate, niazimycin, sitosterol and niazirin (Kayode & Afolayan, 2015; Leone et al., 2016).

Consequently, this study aimed to determine the Minimum Inhibition Concentration of the aqueous ethanolic extract of *M. oleifera* against *Aeromonas hydrophila* bacteria before the growth and immunostimulant effects of *M. oleifera* were tested in any fish.

Material and Method

Preparation of Moringa oleifera Aqueous Ethanolic Extract

Moringa oleifera leaves were collected fresh from Indonesia and brought to Kastamonu. The leaves were dried at room temperature and ground using a high speed mill. For 500 g of plant, 1 L of 30% ethyl alcohol solution was prepared and kept at room temperature for 72 hours according to the method determined by Bilen et al. 2016. Afterwards, the resulting mixture was filtered and then the alcohol and water were removed in an evaporator at 80°C to remove the ethanol (Bilen et al. 2016).

GC-MS Analyses

GC-MS QP2010 Ultra (Shimadzu) equipped with Rtx-5MS column (30m·0.25 mm; coating thickness 0.25 μm) at Kastamonu University Central Research Laboratory was used for the identification of compounds of *Moringa oleifera* extract. The identification of the components was based on comparison of retention times and computer matching according to the Wiley Data library.

Bacterial fish pathogens

Pure cultures of *Aeromonas hydrophila* bacteria were obtained from bacterial cultures previously isolated and identified from rainbow trout in Kastamonu University, Faculty of Fisheries laboratory.

Minimum Inhibition Concentration (MIC) tests

Microdilution method, one of the Minimum Inhibition Concentration tests, was used in the study. In this context, 150 µl of medium was prepared in 96-well plate containing 8 different concentrations (from 2 ppm to 256 ppm) of *Moringa oleifera* aqueous ethanolic extract in 3 replicates.

Results

GC-MS analysis results

The results of chemical analysis of aqueous ethanolic extract of M. oleifera are shown in Table 1. The results of chemical analysis of aqueous ethanolic extract of *M. oleifera* are shown in Table 1. According to the results, Anthraquinone (30.54%), Tannins (25.84%), flavonoids (10.77%) and Terpenoids (11.98%) were the most abundant in the aqueous ethanolic extract of *M. oleifera*.

Tablo 1. Content of *Moringa oleifera* aqueous ethanolic extract

	Components	**Relative Area (%)**
Moringa oleifera	Alkaloids	6.34
	Anthraquinone	**30.54**
	Anthocyanin	0.14
	Cardiac glycoside	0.53
	Carotenoids	0.22
	Flavonoid	**10.77**
	Saponins	4.84
	Steroids	8.77
	Tannins	**25.84**
	Terpenoids	**11.98**

Minimum Inhibition Concentration (MIC) tests results

It was determined that the aqueous ethanolic extract of *M. oleifera* used in the study did not grow after 32 ppm concentration and 64 ppm and higher concentrations were effective on *A. hydrophila* pathogen.

Table 2. MIC test result

Concentration (ppm)	Reproductive state of *A. hydrophila*
256	-
128	-
64	-
32	+
16	+
8	+
4	+
2	+

CONCLUSION

Medicinal plants are broad-spectrum antimicrobial agents and are active against bacteria, viruses, yeasts and other fungi. To date, it is known that there are more than 100,000 bioactive components with pharmacological effects in medicinal plants and that these components can be specific for a family or even for a genus or a species.

According to the results obtained in our study, it is thought that *Moringa oleifera* can be used as a natural antibiotic in fish diseases at concentrations of 64 ppm and above due to its anti-microbial, anti-bacterial and anti-fungal components such as high content of tannin and anthraquinone.

Ethical approval

The author declares that this study complies with research and publication ethics.

Conflicts of interest

There is no conflict of interests for publishing of this study.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Funding organizations

No funding was received for this research.

Author contribution

All three authors contributed equally to this study. Contributions include Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing-original draft, Review and editing.

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Assessment of The Production Performance of Rohu *(Labeo Rohita)* in Cage Culture With Tilapia (*Oreochromis niloticus)*

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Abstract

The present experiment was carried out to assess the growth and production performance Rohu in cage culture with tilapia. The study was conducted over a period of 90 days from August 2022 to November 2022 in Charduani Bazar canal, patharghata upazila. The experiment was designed with three treatments namely T_1 (only tilapia-100%), T_2 (tilapia-80% and rohu-20%) and T_3 (tilapia-60% and rohu-40%) respectively each having three replications (R_1, R_2 and R_3) each cage has 500 fish. Stocking density was 50/m^3. Floating feed was containing 60% variation supplied to the fish during experimental period twice a day at the rate of 5-3% of their body weight. Water quality parameters were recorded in every fifteen days interval throughout the culture period. Physico-chemical parameters, such as water temperature (°C), pH, dissolved oxygen (mg/l), ammonia (mg/l), nitrite (mg/l) and alkalinity (mg/l) hardness (mg/l), salinity (ppt) were measured. The water quality parameters range from temperature 26.2 to 31.7^{0}c, pH 6.2 to 8.3, dissolved oxygen (DO) 4.2 to 5.9 mg/1, ammonia 0.5 to 0.9, nitrite 0 to 0.4, alkalinity 105 to 133, hardness 120 to 148 measured during experimental period. At the end of the culture period higher weight gain of Tilapia (257g) was recorded in T_3 and followed by T_1 (245g) and T_2 (250g) and lowest weight gain of Rohu (90.17g) was observed than T_3 and T_2 (92.1g). Very poor growth of rohu during the study period. The survival rate (%), weight gain, %weight gain, specific growth rate, SGR production were calculated. There were no significand different (P>0.05) among the survival rate of tilapia and Rohu. The survival rate of tilapia range from 94.2 to 96.20% and rohu from 90.15 to 90.50%. The Wight gain, % weight gain and SGR of tilapia and rohu were found higher in T_2, followed by T_3, whereas tilapia showed the higher growth in T_3 and followed by T_2 and T_1. Significantly higher (p>0.05) total production of fish was observed in T_1 (122.46 kg), followed by T_2 (111.16 kg) and T_3 (98.463kg) during study period. The BCR was higher in T_1 (1.67), followed by T_2 (1.62) and T_3 (1.55). The result of the study revealed that culture of Rohu with Tilapia in cage is not suitable because growth performance of Rohu was very poor. During feeding, it was observed that Tilapia showed very aggressive behaviour and due the presence of sharp spine. Rohu were not able to intake sufficient amount of feed.

Keywords: Rohu, tilapia, cage culture, production, feeding

Study on Effect of garlic extract on bacterial disease in shrimp farming

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Abstract

The utilization of garlic in shrimp farming feed mixtures is explored in this study as a potential solution to combat bacterial diseases, particularly Vibriosis caused by *Vibrio parahaemolyticus*. Vibriosis poses a significant threat to shrimp farming, leading to Early Mortality Syndrome (EMS) in young shrimp. Additionally, another prevalent disease in shrimp farming, White Feces Syndrome (WFS), caused by various factors including viral, bacterial, and nutritional imbalances, exacerbates production losses and economic burdens on farmers. This investigation focuses on assessing the antibacterial properties of garlic (*Allium sativum*) extract incorporated into shrimp feed to mitigate both Vibriosis and WFS. This investigation focuses on assessing the antibacterial properties of garlic (*Allium sativum*) extract incorporated into shrimp feed. Results indicate that garlic extract exhibits concentration-dependent antibacterial activity, efficacy in mitigating *Vibrio parahaemolyticus* infections. Incorporating garlic extract into shrimp feed mixtures presents a natural and sustainable approach to enhance disease resistance and improve overall shrimp health. This research contributes to the development of alternative strategies for disease management in shrimp aquaculture, offering a promising avenue for reducing the impact of bacterial diseases and enhancing the sustainability of shrimp farming practices. Implementation of garlic-based feed additives could potentially reduce reliance on conventional antibiotics, thus promoting environmentally friendly and economically viable solutions for the aquaculture industry.

Keyword: Aquaculture shrimp, garlic, white feces, health

Exploration of Nitzschia from the Coastal Waters of Suak Ribee, West Aceh Regency, Indonesia

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Abstract

Indonesia, a critical biodiversity hotspot, harbors diverse ecosystems. Diatoms, siliceous microalgae, are crucial in primary production and oxygen generation globally. With over 100,000 identified species, diatoms exhibit vast morphological diversity influenced by their unique cell division and life cycle. They are significant food sources for zooplankton, contributing to silica sequestration in aquatic environments and vital biological indicators of water quality, responding to environmental changes. The genus Nitzschia, a diverse group comprising nearly 3,000 names classified within the Sigmoideae group, has been found valuable in aquaculture due to its fatty acid content. This study isolates and identifies *Nitzschia*, a diatom from Suak Ribee Beach, West Aceh Regency, Indonesia, utilizing morphological characteristics for species identification. The research aims to contribute to understanding diatom diversity and ecological roles in this coastal environment.

Keywords: *Nitzschia,* Suak Ribee beach, SEM, environment

Harnessing AI for Clearer Waters: Tackling Eutrophication with Smart Technology

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Abstract

Eutrophication, characterized by an overabundance of nutrients in water bodies, poses significant environmental challenges that impact aquatic life, public health, and economic activities. The surplus of nutrients like nitrogen and phosphorus often triggers detrimental algal blooms, depletes oxygen levels, and compromises water quality. To combat eutrophication effectively, it is essential to adopt an integrated management strategy that harnesses data and technological advancements. This study will delve into the capabilities of AI-driven strategies for managing eutrophication, shedding light on their transformative potential in addressing and forestalling this ecological concern.

Keywords: Eutrophication, Nutrients, Aquatic ecosystems, AI-enabled eutrophication management

Impact of Tidal Mixing on Mixed Layer Depth Variability in the Northern Bay of Bengal

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Abstract

This research was conducted to examine the impact of tidal mixing on the Mixed Layer Depth (MLD) in the Northern Bay of Bengal (NBoB), using daily MLD data over a two-year period (2022-2023) from the Copernicus Marine Environment Monitoring Service (CMEMS) data portal. The analysis focused on three regions within the NBoB, determined based on the Simpson-Hunter (SH) parameter calculations which indicate the intensity of tidal mixing. The first region, identified by low tidal mixing (evidenced by a high SH parameter), is located between 85° E–87° E and 18.5° N–20° N. The second region, characterized by high tidal mixing (indicated by a low SH parameter), spans 90° E–92° E and 21° N–23° N. The third region, with moderate tidal mixing, covers 92° E–94° E and 18.5° N–20.5° N. The study's findings reveal average MLD values for regions 1, 2, and 3 to be 14.85, 9.02, and 12.58, respectively. These results suggest that increased tidal mixing in the NBoB leads to a reduction in MLD.

Keywords: Copernicus Marine Environment Monitoring Service, Mixed Layer Depth, Northern Bay of Bengal, Region classification, SH parameter, Tidal mixing

Development of Protocol for Cryoprotection of Climbing Perch *Anabas testudineus* Sperm

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Abstract

Climbing perch *Anabas testudineus* is a freshwater fish that has been introduced for aquaculture. Currently, breeding technology, especially sperm and oocyte storage techniques for climbing perch, is scarcely studied. A good-quality broodfish produces good-quality sperm or oocytes as well. To date, the availability of high-quality brood climbing perch fish is rarely available from the wild; therefore, this is a challenge for researchers. Currently, there are only two studies on cryopreservation (frozen storage) of climbing perch sperm in Indonesia, while studies on oocyte storage are still being examined, and therefore, no report is available. In sperm cryopreservation, there are several materials needed for the cryopreservation process, such as an extender for sperm diluent, cryoprotectant as a material to protect sperm from temperature shock and the negative effects of micro-ice crystals formed during the freezing process, anti-oxidants to reduce the oxidation process (ROS) during the freezing process, and antibiotics to prevent infection with pathogenic microorganisms. The results of the previous studies showed that glucose-based was the best extender for climbing perch, while the best type of cryoprotectant was DMSO at a concentration of 10%, and myo-inositol at 60 mg/L was the best antioxidant. Currently, a study on the suitability of types and concentrations of antibiotics is in progress. It was concluded that research related to climbing perch sperm cryopreservation is still in the development stage and currently shows quite good progress. It is hoped that in the future, a climbing fish sperm cryopreservation method will be produced that is not only beneficial for fish farmers in Indonesia but also abroad.

Keywords: DMSO, Extender, Antioxidant, sperm storage, Liquid nitrogen

Black Soldier Fly Larvae Oil: Application for Sustainable Aquafeed

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Abstract

The need of fish or vegetable oil is increasing as aquafeed industry has improved the aquaculture production to meet the demands of the consumer market. As on the vital component in aquafeed, fish or vegetable oil can be obtained from several fish and vegetables but compete with the human need. Thus, the use of Black Soldier Fly Larvae (BSFL) oil is an alternative which is more sustainable and environmentally friendly. Currently The BSFL oil has the potential to replace fish or vegetables oils. However, little is known about the advantages of BSFL oil and its comparison to fish oil. The purpose of this study was to examine the nutritional components (fatty acid components) of fish oil in comparison to the BSFL oil and assess the advantages of BSFL oil in animal feed. According to the results of the current investigation, the fish growth and other physiological indices has improved when the BSFL oil was added to their diet. Meanwhile, the fatty acid form BSFL oil is comparable to the fish oil, including Omega 3 and Omega 6. The BSFL oil contains fish oil-derived palmitoleic, myristoleic, and tricosanoic acids. The amount of eicosapentaenoic acid (EPA; 20:5n3) found in the BSFL oil is significantly less than the fish oil. Additionally, lauric acid which is associated with antimicrobial qualities is present in the BSFL oil. In conclusion, the BSFL oil has positive effects on the fish's growth and physiological indices, which is viable as aquafeed and more sustainable to substitute fish oil.

Keywords: Aquafeed, Larvae oil, Sustainable

Reproductive parameters of pike perch *Sander lucioperca* (Linnaeus, 1758) in the Al Massira Dam Lake (Morocco)

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Abstract

The pike perch *Sander lucioperca* (Linnaeus, 1758) is one of the key species in the Al Massira Dam Lake and the local fishing community in Morocco. Due to its high socio-economic value, it predominates in fisheries catches. This investigation aimed to determine the spawning season and to study the reproductive patterns of females *Sander lucioperca* in Moroccan freshwater. For this purpose, a total of 720 individuals caught in the Al Massira Dam Lake were sampled from March 2019 to February 2020. Macroscopic analysis of the gonads, combined with monitoring of the monthly evolution of the gonado-somatic index, the hepato-somatic index and the condition factor, have made it possible to elucidate the sexual modalities of the reproductive cycle of pike perch females. Thus, gametogenesis in this species takes place during autumn, winter and early spring, with a single oviposition in spring between April and May and sexual rest in summer (June-August). Sexual maturity occurs early, and the overall sex ratio was in the favour of females (1: 0.52 female to male). Those biological data are indispensable for the assessment of the stock of this species.

Keywords: *Sander lucioperca,* Al Massira Dam Lake, spawning season, gonado-somatic index, reproductive cycle.

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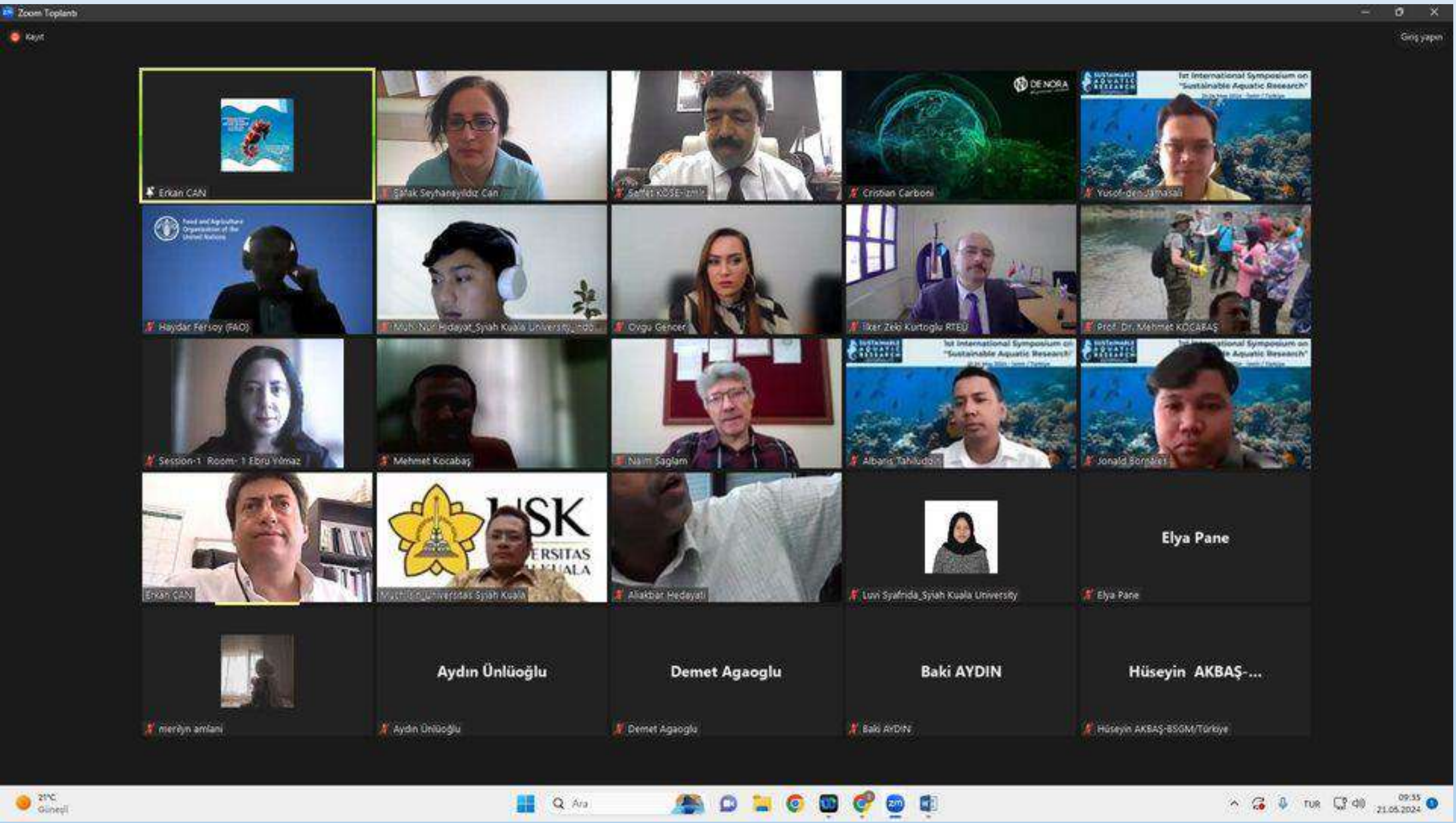

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