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Sustainability in Aquaculture through Microalgae from the Perspective of Islamic Ethics: A Literature Review

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Abstract

The aquaculture industry is expected to expand due to the newest technologies that can produce yields of higher quality. Sustainability is now a top concern in the aquaculture industry due to growing obstacles in the production of aquaculture products, including pollution of the environment, dependence on non-sustainable food sources, and issues with food safety. Due to their dual roles as a biofilter and an alternate food source, microalgae are considered a natural resource with significant potential to improve the sustainability of aquaculture systems. This study aims to conduct a scientific literature review regarding the role played by microalgae in the aquaculture practice and connect it with Islamic ethical principles such as *tawazun* (balance), *amanah* (trust), and *maslahah* (public welfare). Document analysis in a qualitative manner was conducted through the research approach of the publications in the various journals, scientific articles, theses, and research on aquaculture science and Shariah principles. The study shows that microalgae use helps in the sustainable and cleaner aquaculture production and maintains the Islamic value that emphasize human responsibility as caliphs in maintaining the sustainability of nature. The research indicates the need for integration of the values in Islam and in science as the basis for developing sustainable and ethical aquaculture innovation and policy.

Keywords: Aquaculture, Microalgae, Sustainability, Islamic

1. Introduction

The aquaculture industry, encompassing the farming of aquatic organisms such as fish, shellfish, and aquatic plants, plays a vital role in global food security, economic development, and poverty alleviation (Faudzi et al., 2024; Dong, 2023). However, this crucial sector is simultaneously grappling with significant environmental challenges. These include pervasive water pollution stemming from fish waste and excess nutrients, an unsustainable reliance on capture fisheries for feed, increased use of pharmaceuticals, the frequent occurrence of infectious outbreaks, and complex solid/liquid waste management issues (Faudzi et al., 2024; Nagarajan et al., 2024). Nitrogen pollution, particularly from ammonia and nitrite, presents a major concern, highlighting the urgent need for environmentally friendly and economically feasible treatment methods (Bhambri et al., 2023). Furthermore, the overarching impacts of climate change, such as ocean acidification and nutrient runoff, introduce additional layers of complexity to aquaculture sustainability (Moss et al., 2025).In response to these multifaceted challenges, microalgae offer a highly promising and multifaceted sol ution. These remarkable organisms are capable of carbon mitigation, bioremediation, and nutrient recovery, making them indispensable tools for improving water quality and enhancing aquatic animal health (Nagarajan et al., 2024). Beyond their environmental benefits, microalgae can effectively replace conventional raw materials like fish oil and meal in aquafeeds, thereby reducing dependence on wild-caught resources and simultaneously boosting the nutritional quality of farmed products (Bhambri et al., 2023; Lu et al., 2021). Their role extends to wastewater treatment, where algal biomass can be converted into valuable resources such as biofuel, fish feed, and fertilizer, thus actively supporting a circular economy model (Sarker & Kaparaju, 2025; Han et al., 2019). The synergistic interactions between microalgae and bacteria further optimize nutrient cycling and wastewater treatment efficiency, contributing significantly to overall ecological sustainability (Ali et al., 2025; Natrah et al., 2014).

Beyond technological solutions, integrating Islamic ethical principles into aquaculture practices offers a profound pathway to promote both sustainability and the ethical treatment of aquatic animals. Islamic ethics inherently emphasize core values such as environmental protection, fairness, active stakeholder participation, harm prevention, beneficence, and trustworthiness (Cooper et al., 2023). These principles are inherently aligned with the overarching goals of sustainable aquaculture, ensuring the responsible management of natural resources and the humane treatment of animals within the industry (Ciliberti et al., 2023; Gonzalez, 2025). Moreover, the increasing global demand for halal-certified products necessitates adherence to Islamic dietary laws, which can be seamlessly integrated with contemporary concerns regarding food safety, sustainability, and ethical animal welfare (Elegbede et al., 2025). This holistic integration has the potential to foster greater consumer trust and encourage more responsible practices across the entire aquaculture sector (Ciliberti et al., 2023).

While microalgae offer promising technological solutions for bioremediation, nutrient recovery, and sustainable feed production (Nagarajan et al., 2024; Bhambri et al., 2023), there remains a significant gap in comprehensively integrating these scientific advancements with robust ethical frameworks to guide truly sustainable and responsible aquaculture practices. Specifically, the potential for Islamic ethical principles to inform and enhance aquaculture sustainability has not been adequately explored or conceptualized in conjunction with specific technological solutions like microalgae. This lack of an integrated ethical and scientific perspective hinders the development of holistic and universally accepted sustainable aquaculture policies and innovations. Therefore, this study employs a document analysis approach to examine literature, including books, scholarly articles, journals, and theses, pertaining to both Sharia principles and aquaculture science. The primary aim is to conduct a scientific literature review on the role of microalgae in aquaculture systems and to critically connect this role with fundamental Islamic ethical principles.

2. Research Methodology

This study adopted a qualitative research design, primarily employing a document analysis approach to systematically examine existing literature. This methodology was chosen for its suitability in exploring complex concepts and synthesizing diverse perspectives from various scholarly sources. Data for this study were collected through a comprehensive search and compilation of relevant academic documents. The selection criteria focused on literature pertaining to two primary domains: aquaculture science and Islamic Sharia principles, with a specific emphasis on their intersection with sustainability and environmental ethics. The types of documents included in this analysis were peer-reviewed journals, scholarly articles, theses and dissertations, and books, all providing foundational knowledge and theoretical frameworks.

3. Findings and Discussion

3.1 The Use of Microalgae to Reduce Water Pollution in Farming Systems

Utilizing microalgae to enhance the quality of rearing water is a highly effective and environmentally friendly strategy, as it helps mitigate pollution by absorbing excess nutrients and various waste compounds (Jakhwal et al., 2024). Microalgae are widely acknowledged for their efficiency, sustainability, affordability, and simplicity compared to conventional wastewater treatment systems (Huang et al., 2024). They have proven capable in purifying and treating water following aquaculture activities. Additionally, the oxygen generated through algal photosynthesis plays a key role in lowering both chemical oxygen demand (COD) and biological oxygen demand (BOD) in wastewater (Khan et al., 2018; Huang et al., 2024). Their compact structure, coupled with a large surface area and the ability to form dense colonies or biofilms, allows microalgae to absorb significant amounts of nutrients from wastewater (Jakhwal et al., 2024). Ammonia is among the most prevalent nitrogen-based pollutants in aquaculture systems, mainly resulting from the breakdown of proteins and the excretion of waste by cultured aquatic animals. *Chlorella* strains, known for their high ammonia uptake and ability to accumulate protein, present a promising solution by efficiently assimilate ammonia from wastewater or growth media. This not only helps reduce nitrogen pollution but also yields biomass with protein content exceeding 50% of its dry weight, making *Chlorella* a valuable, protein-rich ingredient for aquaculture feed (Pang et al., 2021; Afrin et al., 2025). Microalgae play a vital role in enhancing the sustainability of aquaculture systems by naturally improving water quality. They can proliferate within rearing environments and effectively remove specific dissolved wastes, contributing to the system's overall cleanliness (Pekkoh et al., 2022). Their ability to assimilate essential nutrients, particularly carbon, nitrogen, and phosphorus not only supports their growth but also significantly reduces the risk of eutrophication in surrounding water bodies (Lopes et al., 2021). When introduced into fish or shrimp tanks and ponds, microalgae boost the self-purification capacity of the system by breaking down organic waste and helping to stabilize dissolved oxygen levels (Chen et al., 2023; Afrin et al., 2025). Furthermore, the development of targeted microalgae cultivation systems allows for efficient nutrient recovery from aquaculture effluents, making them an effective and eco-friendly solution for wastewater management (Vazquez-Romero et al., 2024).

Microalgae-based wastewater treatment offers substantial promise as an alternative to conventional treatment approaches (Huang et al., 2022). Microalgae exhibit a wide range of beneficial characteristics, including high photosynthetic efficiency, oxygen generation, effective carbon dioxide absorption, rich lipid content, rapid growth, and strong adaptability to diverse environmental conditions. These attributes enable them to absorb nutrients from wastewater and enhance the quality of rearing water (Li et al., 2017; Mirzaei et al., 2024). Additionally, their presence contributes to improved health and well-being of cultured aquatic animals (Huang et al., 2022; Shi et al., 2024). As a result, microalgae serve as an ideal biological agent for integrated and sustainable wastewater management (Huang et al., 2022).

Algae have the ability to treat a wide range of wastewater components, including nutrients such as nitrogen, phosphorus, carbon dioxide (CO_2), chemical oxygen demand (COD), as well as various minerals and metals (Chan et al., 2022). Ammonium, which is produced through the decomposition of organic waste or the reduction of nitrate, is utilized by algae for amino acid synthesis, contributing to protein formation (Roveda et al., 2024). In contrast, inorganic phosphorus is used in the synthesis of ribosomal RNA or stored as polyphosphate within algal cells (Jakhwal et al., 2024). Microalgae exhibit strong potential in enhancing the quality of rearing water through the removal of excess nutrients (Alsarayreh et al., 2022; Markou et al., 2024). They can effectively absorb and eliminate nitrogen and phosphorus from aquaculture water without generating secondary pollution (Ende et al., 2024). Following phycoremediation treatment, the treated water typically exhibits lower ammonia concentrations and higher dissolved oxygen (DO) levels, leading to improved water quality and indirectly supporting the health and growth of aquatic organisms (Huang et al., 2022; Shi et al., 2024). Without the application of this treatment, the accumulation of ammonia can be toxic to aquatic life and may result in high mortality rates (Martelli et al., 2024). Huang et al. (2022) highlighted several positive impacts of integrating microalgae into intensive *Litopenaeus vannamei* (white leg shrimp) culture systems. This practice contributes to the stabilization of pH and elevation of dissolved oxygen (DO) levels, while simultaneously reducing the accumulation of nitrogenous and phosphorous compounds such as nitrate, nitrite, total ammonia nitrogen (TAN), phosphate, and total suspended solids (Ding et al., 2021; Mirzaei et al., 2024). Moreover, the presence of microalgae has been associated with the suppression of *Vibrio* spp. proliferation in rearing environments, which is critical in minimizing disease outbreaks (Wang et al., 2023a, 2023b). Collectively, these factors support enhanced shrimp growth performance, increased production yield, and improved feed conversion ratios (FCR) (Huang et al., 2022).

Among the various species studied, *Chlorella sp.* has emerged as a leading candidate for nutrient remediation in aquaculture systems, particularly for its effectiveness in assimilating ammonia and phosphorus from wastewater (Pang et al., 2021; Chen et al., 2023; Afrin et al., 2025). When applied in conjunction with continuous bio-harvesting methods, *Chlorella sp.* has demonstrated strong potential as a sustainable solution for wastewater treatment and water recirculation in intensive aquaculture operations (Pang et al., 2021). In addition to *Chlorella*, several other microalgal genera, including *Nannochloropsis* (Ding et al., 2021; Shi et al., 2024), *Tetraselmis* (Khatoon et al., 2021; Iba et al., 2024), *Spirulina* (Zhou et al., 2017; Mata et al., 2020), *Scenedesmus* (Li et al., 2022; Silva et al., 2022), *Ankistrodesmus* (Okomoda et al., 2021), *Chaetoceros* (Castine et al., 2013; Schveitzer et al., 2017), *Arthrospira platensis* (Mirzaei et al., 2024), *Platymonas* (Dong et al., 2022; Ge HongXing et al., 2016), *Euglena* (Tossavainen et al., 2019), *Oscillatoria* (Xu et al., 2019), and *Golenkinia* (Moawad et al., 2024), have shown varying capacities to absorb key pollutants such as ammonia, nitrate, nitrite, and chemical oxygen demand (COD). Among these, *Chlorella*, *Scenedesmus*, and certain cyanobacteria are the most frequently utilized in aquaculture wastewater treatment due to their rapid growth rates, high environmental tolerance, and considerable potential for lipid and starch accumulation (Afrin et al., 2025). Studies involving microalgae species such as *Chaetoceros muelleri* and *Thalassiosira weissflogii* have shown pollutant removal efficiencies exceeding 80% (Tang et al., 2020). Similarly, a comparative study evaluated the bioremediation potential of four microalgal species; *P. gyrans*, *P. tricornutum*, *T. suecica*, and *N. oculate*, in treating aquaculture rearing water (Jakhwal et al., 2024). Beyond nutrient removal, the incorporation of microalgae into fish rearing tanks or ponds also helps suppress the growth of harmful or toxic microorganisms, thereby creating a more favorable environment for aquatic animals (Vazquez-Romero et al., 2024; Farrag et al., 2024). As a result, the need for frequent water replacement is reduced, leading to considerable cost savings in aquaculture operations (Chen et al., 2023; Afrin et al., 2025).

3.2 A More Sustainable Alternative Food Source Compared to Pellets

Microalgae have emerged as a promising alternative to traditional feed ingredients in aquaculture due to their ability to synthesize a wide range of value-added components, including proteins, lipids, antioxidants, and natural pigments. Various species such as Chlorella sp., Dunaliella sp., and Scenedesmus sp. have been successfully utilized for the production of nutrient-rich biomass, which not only reduces dependence on conventional feed but also enhances the immunity and overall health of aquatic animals (Lu et al., 2017; Ansari et al., 2017; Sirakov et al., 2015). In aquaculture systems, microalgae serve as essential nutritional sources for fish and shrimp, either through direct consumption or as incorporated ingredients in formulated feeds. Compared to conventional feed ingredients like soybean or peanut meal, microalgae offer several advantages. They are naturally rich in proteins, lipids, carbohydrates, and polyunsaturated fatty acids (PUFAs), all of which are crucial for the optimal growth and development of aquatic species. Furthermore, the nutrient composition of microalgae can be tailored through genetic regulation and controlled growth conditions to produce higher levels of desirable compounds such as antioxidants and pigments (Li et al., 2018; Choubert et al., 2006).

From a practical standpoint, microalgae-based feed offers multiple benefits. First, their high protein and carbohydrate content make them suitable partial replacements for fishmeal, thereby lowering feed costs. Second, the presence of natural antioxidants in microalgae enhances the immune response of aquatic animals, providing a sustainable alternative to antibiotics, which are often overused in aquaculture. Third, specific microalgal components, particularly pigments like astaxanthin, play a critical role in the growth, flesh quality, and market value of certain fish species. For example, astaxanthin is essential in the salmon industry, where flesh coloration is a key quality attribute (Han et al., 2019). Compared to plant-based proteins like those from soybean, microalgae exhibit significantly higher productivity, making them a more sustainable protein source. Previous studies have reported improved feed conversion ratios (FCR) in fish fed with microalgae-enriched diets, demonstrating better feed efficiency than traditional feeds (Li et al., 2014). Additionally, microalgae are a superior source of PUFAs, including omega-3 fatty acids, which are less abundant in conventional feedstocks. Their inclusion in aquafeeds offers improved nutritional value, contributing to both fish health and the nutritional quality of fish for human consumption. Natural pigments in microalgae, such as astaxanthin, chlorophyll, and carotene, are also important for fish growth and immune function. For instance, *Haematococcus pluvialis*, a rich source of astaxanthin, has been shown to enhance flesh pigmentation in *Oncorhynchus mykiss* (rainbow trout), increasing its market appeal [Choubert et al., 2006]. Furthermore, studies on *Pseudosciaena crocea* (large yellow croaker) indicate that increased dietary intake of astaxanthin correlates with enhanced lysozyme activity, a key indicator of immune health (Li et al., 2014). Incorporating microalgae biomass rich in natural pigments directly into aquafeeds not only reduces production costs but also helps preserve pigment stability and bioavailability. This integrated approach aligns with sustainable aquaculture practices by improving feed quality, promoting fish health, and minimizing environmental impacts (Han et al., 2019).

In the context of sustainable aquafeeds, the marine microalga *Nannochloropsis* sp. emerges as a promising alternative to fishmeal in the diets of farmed rainbow trout and Atlantic salmon, primarily due to its rich protein content and significant levels of long-chain polyunsaturated fatty acids (LC-PUFAs), both of which are essential for optimal fish growth and health (Sarker et al., 2020; Tibbetts et al., 2015; Sarker et al., 2018).A recent study conducted by Sarker et al. (2025) demonstrated that a diet with complete fishmeal replacement supported fish growth, feed conversion, and survival rates comparable to those of the reference diet. There were no significant differences in the fillet composition in terms of macronutrients, amino acids, fatty acids, macro minerals, and selected trace elements across the different dietary treatments. Moreover, the economic conversion ratio (ECR) analysis revealed that rainbow trout fed the 100% microalgae-based diet incurred the lowest feed cost per kilogram of fish produced. These findings showed that microalgal co-products can entirely replace fishmeal in trout feed without compromising fish performance, flesh quality, or economic efficiency. Another study demonstrated that a complete replacement of fishmeal (FM) and fish oil (FO) with a combination of two marine microalgae—*Nannochloropsis oculata* defatted biomass and *Schizochytrium* sp., in the diet of Nile tilapia (*Oreochromis niloticus*) resulted in superior performance metrics. These included higher final body weight, weight gain, percentage weight gain, specific growth rate, and protein efficiency ratio, all comparable to those observed in fish fed a conventional FM and FO-based diet (Sarker et al., 2020). Compared to conventional crop-based ingredients, marine microalgal biomass also offers a reduced environmental footprint. It requires less arable land, and is capable of producing at least twice the biomass, along with significantly greater oil and protein yields per hectare than soybeans (Van Krimpen et al., 2013; Bhatnagar et al., 2024). Moreover, marine microalgae can be cultivated using saline or wastewater on non-arable land, thereby minimizing competition with agriculture for freshwater and fertile soil resources (Ansari et al., 2021).

3.3 Supports Fish Growth Without Relying on Antibiotics and Harmful Chemicals

Microalgae-based feed has shown great promise in enhancing the immune response of aquatic animals, thereby reducing reliance on antibiotics and chemical therapeutics in aquaculture systems (Ding et al., 2021; Huang et al., 2022; Shi et al., 2024). This immunostimulatory effect not only contributes to improved animal health and welfare but also enhances the safety and quality of aquaculture products, leading to increased consumer acceptance and market value (Mujtaba & Lee, 2017). Products free from chemical residues or contaminants are generally more desirable and fetch higher prices in both local and global markets (Ighalo et al., 2022). Several microalgal strains cultivated under controlled conditions have exhibited strong anti-Vibrio activity through the production of antimicrobial compounds, such as tropodithietic acid, which are effective in suppressing pathogens like *Vibrio parahaemolyticus*, the causative agent of acute hepatopancreatic necrosis disease (AHPND) (Yang et al., 2019; Wang et al., 2023a, 2023b). In addition to nutrient removal, the incorporation of microalgae into aquaculture systems contributes to water quality management by releasing extracellular compounds that inhibit the growth of pathogenic bacteria (Dong et al., 2022; Yang et al., 2019). In the culture of *Litopenaeus vannamei*, dietary supplementation with microalgae has been reported to improve growth performance, survival rates, and feed conversion efficiency (Dong et al., 2022; Shi et al., 2024). These benefits highlight the potential of microalgae to reduce the dependency on chemical inputs and support more sustainable production systems (Hashmi et al., 2023). Moreover, the development of microalgae–bacteria consortia represent a novel strategy to enhance nutrient removal, foster mutualistic microbial interactions, increase microbial biodiversity in rearing environments, and lower the prevalence of disease (Geng et al., 2022). Microalgae contain value-added bioactive compounds such as polyunsaturated fatty acids (PUFAs), astaxanthin, and carotenoids that have been shown to enhance fish immunity. Studies have indicated that incorporating marine microalgae as alternative ingredients to fish meal can stimulate immune responses in cultured species, highlighting their potential as effective immunostimulants (Messina et al., 2019). Additionally, natural pigments like carotene and chlorophyll present in microalgae contribute to immune enhancement and may lower the risk of disease outbreaks in aquaculture systems (Mustafa et al., 2011). The natural pigments produced by microalgae not only enhance the visual appeal of products but also provide health benefits due to their antioxidant properties. For instance, *Chlorella sorokiniana* cultivated under mixotrophic conditions yields high levels of lutein, a potent antioxidant suitable for use as a dietary supplement with potential health-promoting effects (Chen et al., 2019; Fu et al., 2023). Additionally, astaxanthin extracted from *Haematococcus pluvialis* has been incorporated into diets to enhance growth and pigmentation in ridgetail white prawn (*Exopalaemon carinicauda*) (Zhang et al., 2021).

Moreover, the presence of beneficial microalgae can suppress pathogenic blooms, thereby promoting a healthier rearing environment. Research conducted by Chen et al. (2020) indicates that analysis of bacterial counts and community profiles suggests the presence of microalgae in aquaculture systems contributes to improved water quality and a more conducive environment for fish growth. By suppressing the proliferation of pathogenic bacteria, microalgae help lower disease incidence among cultured species (Broszat, et al., 2014). Consequently, this biological approach can significantly reduce the reliance on antibiotics in aquaculture practices.

3.4 Islamic Environmental Ethics: The Principle of *Tawazun* (Balance)

Islam outlines comprehensive ethical principles for environmental stewardship, rooted in divine values, balance, and humanity's responsibility as caliph on Earth. The principle of *tawazun*, or balance, is a fundamental basis for humanity's relationship with nature. Allah (SWT) created this universe with a balanced and interdependent ecology and ecosystem (Munawarah, 2021). Every creation and phenomenon has its own function and role. Imbalance occurs due to excessive human intervention, such as over-logging, and air and water pollution, leading to overall ecosystem degradation. Therefore, Muslims are urged to maintain this balance as a sign of obedience to their Creator. From an Islamic philosophical perspective, environmental preservation is inseparable from humanity's relationship with God. HAMKA emphasized that nature contains profound philosophical value, reflecting divine majesty and serving as a guide for human life. The current environmental crisis reflects humanity's failure to understand nature as a trust from God, a consequence of a secular worldview that separates nature from divine values. Seyyed Hossein Nasr also criticized the modern human rights approach, which emphasizes individual freedom while neglecting moral and spiritual responsibility towards the environment. He asserted that solving the ecological crisis requires a holistic approach based on religious values, and humans must return to their original role as Allah's stewards, caring for the Earth with full responsibility. Therefore, ecological awareness in Islam must be centered on a divine philosophy that harmoniously and balancely connects nature, humanity, and God (Zul ‘Azmi, 2012; Zul'azmi Yaakob & Zailan Morris).

3.5 Islamic Framework for Prohibition of Waste and Pollution

Islam establishes a clear framework for fair management of natural resources and wealth, based on the Qur'an. Allah (SWT) commands that all Earth's resources, such as agriculture, livestock, forestry, petroleum, and minerals, be managed wisely, distributed equitably, and utilized for the common good, not monopolized by the elite or powerful. This principle is affirmed in Surah al-Hashr, verse 7:

“As for gains granted by Allah to His Messenger from the people of other lands, they are for Allah and the Messenger, his close relatives, orphans, the poor, and needy travellers so that wealth may not merely circulate among your rich. Whatever the Messenger gives you, take it. And whatever he forbids you from, leave it. And fear Allah. Surely Allah is severe in punishment.” (al-Quran 59:7).

According to al-Sa‘di (2018), this verse illustrates a divine economic policy that avoids the concentration of wealth among a few individuals. This teaching is crucial in the context of da'wah (inviting to Islam) as it calls for justice and compassion in managing societal resources. Environmental protection is not just an ecological issue, but also a social and economic responsibility of Muslims.

In another verse, Surah al-A‘raf, verse 56, Allah says:

“Do not spread corruption in the land after it has been set in order. And call upon Him with hope and fear. Indeed, Allah’s mercy is always close to the good-doers.” (al-Quran 7:56).

This verse sternly warns against corrupting the Earth after it has been set in order. Environmental damage such as pollution, deforestation, or excessive resource exploitation is classified as *fasād* (corruption) in Islam (Ahmad Munawar & Mohd Farhan, 2024). Therefore, Islam calls for responsible development that aligns with Allah's laws. When humans pursue profit without guidance from the Qur'an and Sunnah, they contribute to an environmental crisis that threatens global life. Furthermore, Prophet Muhammad (SAW) reminded that the Earth and all its blessings are a trust. Islam encourages the preservation (*hifz*) and restoration (*i‘ādat al-‘imār*) of the Earth. If development is carried out excessively or unethically, it can lead to irreversible damage (Abur Hamdi & Mohd Norzi, 2023). Therefore, da'wah needs to go beyond mere spiritual rhetoric and encourage individuals and institutions to become khalifah who develop the Earth with moderation and responsibility. As stated by Syahrul Basri et al. (2025), Islamic environmental management principles are gaining global attention due to their comprehensive and practical approach to addressing modern problems through the integration of ethical, spiritual, and social values.

3.6 Humanity's Trust as Khalifah (Caliph)

In line with this, the Qur'an reminds humanity of their position as khalifah on Earth, as stated by Allah (SWT) in Surah al-Baqarah, verse 30: *“Remember when your Lord said to the angels, I am going to place a successive human authority on earth...”.* This position is not a privilege to be abused, but a great trust that demands responsibility and integrity. Humans are given the ability to administer and develop the Earth, but they are also accountable for all actions that affect nature (Ibn Kathir, 1969). In this context, the role of da'wah is crucial in educating society to understand that any damage to the environment is a betrayal of the trust given by Allah (SWT).

Additionally, in Surah al-Baqarah, verse 60, Allah (SWT) reminds:

"...Eat and drink of Allah’s provisions, and do not go about spreading corruption in the land." (al-Quran 2:60).

This verse emphasizes that blessings like water are gifts from Allah that must not be misused. Tafsir al-Misbah explains that this verse prohibits wastefulness that leads to environmental harm (Muhammad Quraish, 2002). In the context of da'wah, this verse stresses that true gratitude is not only through words but also through actions that avoid destruction. Effective da'wah needs to educate society that caring for the environment is a form of worship and obedience to Allah (SWT) (Imaaduddin & Noor Shakirah, 2016).

Furthermore, Surah al-A‘raf, verse 74 states:

"...So remember Allah’s favours, and do not go about spreading corruption in the land.” (al-Quran 7:74).

This verse refers to the Thamud people who were given technological advantages and the ability to build dwellings from mountains, but ultimately disbelieved in Allah. Tafsir al-Maraghi states that although they built an advanced civilization, they were destroyed for denying Allah's guidance (al-Maraghi, 2001). Within the framework of da'wah, this verse teaches that knowledge and progress are trusts that must be used in harmony with divine values. Da'wah should call for balanced progress based on *tawhid*, not boundless exploitation.

In Surah al-Isra’, verse 37, Allah (SWT) says:

“And do not walk on the earth arrogantly. Surely you can neither crack the earth nor stretch to the height of the mountains." (al-Quran 17:37).

According to Tafsir al-Misbah, this verse reminds humans of their limitations and that arrogance will lead to Allah's wrath (Muhammad Quraish, 2002). This trait is evident today in issues like illegal logging, where some parties destroy nature for personal gain. In da'wah, it is important to instill the quality of *tawadhu’* (humility) so that humans realize they are merely servants of Allah and guardians of His creation.

3.7 Concepts of *Maslahah* (Public Welfare) and *La Darar Wa La Dirar* (No Harm)

Islamic environmental ethics are also based on the concept of *maslahah* (public welfare) and the principle of *la darar wa la dirar*. According to Zaydan (2020), the fiqh principle of *la darar wa la dirar* means no harm shall be inflicted or reciprocated. It is one of the five foundational principles in Islamic law used to evaluate human actions. The word *darar* means something harmful or damaging, while *dirar* has two interpretations: some scholars say it is the same as *darar*, and another view associates *dirar* with retaliating harm in an unjust way. Whatever its meaning, this principle emphasizes that all forms of harm must be avoided and eliminated. Muslims must refrain from actions that could harm themselves, others, society, or the environment. If something can cause harm, Islam teaches that it should be prevented from the outset, stopped if it is occurring, or replaced with a better method. This principle demonstrates Islam's strong emphasis on justice, well-being, and shared responsibility in life. Therefore, this principle emphasizes that any action or development undertaken must bring comprehensive good, encompassing humans, nature, and all of Allah (SWT)'s creations on Earth. Conversely, any actions that lead to harm, such as uncontrolled deforestation, toxic waste disposal, or unsustainable development, are contrary to Islamic values (Kalsom Awang & Mohd Zahirwan Halim Zainal Abidin, n.d.). In the context of da'wah, this approach demands that Muslims understand that environmental stewardship is not merely a technical or scientific issue, but a *shar'ie* (religious law) responsibility with significant implications for the well-being of the *ummah* (Muslim community).

3.8 Islamic Ethical Reflections on the Use of Microalgae in Sustainable Aquaculture

Table 1 presents a summary of the preceding discussion.

Table 1: Summary of the Discussion on Aquaponic Systems from an Islamic Ethical Perspective

Aquaculture Aspects	**Islamic Perspective**
Water pollution from farm waste	Prohibiting corruption on Earth (fasad fil ard)
Unsustainable use of resources	Responsibility towards the balance of nature
Microalgae as a natural alternative	Avoiding harm (*la darar wa la dirar*) and maintaining health
Water quality and the cleanliness	The concept of *taharah* (purity/cleanliness) and *mas'uliyyah* (the responsibility of care)
Halal status of food sources for aquatic animals	Affects the halal status of the final product consumed by humans
Ecosystem sustainability	Aligns perfectly with humanity's responsibility as khalifah (caliph) of the Earth
Environmentally friendly biotechnology innovation	Ethical advancement of science that safeguards the rights of all creatures

4. Conclusion

The aquaculture industry, while vital for global food security, faces significant and escalating sustainability challenges, including environmental degradation, reliance on unsustainable feed, and food safety concerns. This study has underscored the critical need for innovative and ethically grounded approaches to ensure the long-term viability of this sector. Our comprehensive literature review has highlighted microalgae as a highly promising natural resource, capable of enhancing aquaculture sustainability through their dual functions as effective biofilters and alternative, nutritious feed sources. Crucially, this research has demonstrated that the scientific application of microalgae in aquaculture not only contributes to cleaner and more sustainable production practices but also aligns profoundly with Islamic ethical principles. Specifically, the principles of *tawazun* (balance), *amanah* (trust), and *maslahah* (public welfare) provide a robust ethical framework that resonates with the environmental and social responsibilities inherent in sustainable aquaculture. The qualitative document analysis conducted in this study revealed a clear synergy between these scientific and ethical dimensions. In essence, the findings affirm that the use of microalgae supports more sustainable and environmentally responsible aquaculture, directly reflecting the Islamic emphasis on humanity's role as *khalifahs* (caliph) entrusted with preserving the natural world. Therefore, this study strongly advocates for the integration of scientific advancements with Islamic values as a foundational approach. This holistic integration is essential for developing comprehensive, ethical, and truly sustainable aquaculture policies and innovations that can meet future demands while upholding ecological integrity and moral responsibility.

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