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Utilization of *Lemna minor* as an Ammonia Phytoremediator at Kampoeng Pintar Oase Surabaya

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ABSTRACT

Increasing food demand and high land use activities have led to the conversion of fisheries and agricultural areas. Kampoeng Pintar Oase Surabaya uses budikdamber (fish farming in buckets) as an alternative solution for small areas. Budikdamber produce ammonia from food waste and fish feces which can reduce water quality requiring environmentally friendly ammonia management solutions. This study aims to describe the effect of Lemna minor on ammonia reduction in budikdamber systems, the lowest ammonia level achieved after Lemna minor addition, the impact of ammonia reduction on catfish growth, and to assess the application of Lemna minor in budikdamber systems in supporting the achievement of SDG 2. The research was conducted in two stages. The first stage involved the creation of a pond culture medium using the observation method. The second stage was experimental, involving the implementation of pond culture for 21 days using two treatments, namely a control (without Lemna minor) and a treatment with the addition of Lemna minor, each of which was repeated three times. The parameters measured included ammonia levels, total nitrogen, pH, temperature, and DO. Data analysis was performed descriptively and quantitatively by testing ammonia and total nitrogen levels at BSPJI Surabaya based on the SNI 6484.4:2014 water quality standards. The results showed that the addition of Lemna minor reduced ammonia levels lower than the control treatment. The lowest ammonia level achieved was 0.72 mg/L on the 7th day. The best catfish growth was observed in the Lemna minor treatment with an average weight of 46 grams. Lemna minor is effective as an ammonia phytoremediator and supports fish growth in fish farming in buckets, as well as supporting the achievement of SDG 2 "Zero Hunger" through strengthening sustainable food security.

Kata Kunci
Lemna minor
Amonia
Fitoremediator
Budikdamber
Ikan lele
SDG 2

Pemanfaatan Lemna minor sebagai Fitoremediator Amonia di Kampoeng Pintar Oase Surabaya. Meningkatnya kebutuhan pangan dan tingginya aktivitas pemanfaatan lahan menyebabkan alih fungsi area perikanan dan pertanian. Kampoeng Pintar Oase Surabaya menggunakan budikdamber sebagai salah satu alternatif di lahan sempit. Budikdamber menghasilkan amonia dari sisa makanan dan feses ikan yang dapat menurunkan kualitas air sehingga diperlukan solusi pengelolaan amonia yang ramah lingkungan. Penelitian ini bertujuan untuk mendeskripsikan pengaruh pemberian Lemna minor terhadap penurunan kadar amonia pada sistem budikdamber ikan lele, kadar amonia terendah yang dicapai setelah pemberian Lemna minor, dampak penurunan kadar amonia terhadap pertumbuhan ikan lele, dan mengkaji penerapan Lemna minor pada sistem budikdamber ikan lele dalam mendukung pencapaian SDG 2. Penelitian dilakukan dalam 2 tahap, tahap pertama adalah pembuatan media budikdamber dengan metode observasi. Tahap kedua adalah eksperimental dengan implementasi budikdamber selama 21 hari menggunakan dua perlakuan, yaitu kontrol (tanpa pemberian Lemna minor) dan perlakuan dengan pemberian Lemna minor yang masing-masing dilakukan dengan tiga kali ulangan. Parameter yang diukur meliputi kadar amonia, total nitrogen, pH, suhu, dan DO. Analisis data dilakukan secara deskriptif kuantitatif dengan uji kadar amonia dan total nitrogen di BSPJI Surabaya berdasarkan baku mutu kualitas air SNI 6484.4:2014. Hasil penelitian menunjukkan bahwa pemberian Lemna minor mampu menurunkan kadar amonia lebih rendah daripada perlakuan kontrol. Kadar amonia terendah yang dicapai sebesar 0,72 mg/L pada hari ke-7. Pertumbuhan ikan lele terbaik pada perlakuan Lemna minor dengan rata-rata berat 46 gram. Lemna minor efektif sebagai fitoremediator amonia dan mendukung pertumbuhan ikan pada sistem budikdamber serta mendukung pencapaian SDG 2 yaitu "Zero Hunger" melalui penguatan ketahanan pangan berkelanjutan.

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INTRODUCTION

Kampoeng Pintar Oase Tembok Gede is an educational tourism village located on Jl. Jawa Tembok Gede III, Ketabang Village, Bubutan District, Surabaya City. Since its inauguration in 2018, this village has developed into an urban farming area that optimizes limited urban land through various innovations. The innovations implemented include the use of used pipes as a medium for plant cultivation with tower garden, hydroponic, and aquaponic systems, organic waste management using tube composters, and budikdamber as a form of integrated sustainable food systems (Naghiesa *et al*., 2024). Urban farming is a promising solution to the challenges of food supply and the negative impacts of urbanization (Giyarsih *et al*., 2024). Kampoeng Pintar Oase Tembok Gede is also an area developed by the Surabaya Food Security and Agriculture Agency (DKPP) in order to strengthen food security (Wedowati *et al*., 2024).

One of the activities developed at Kampoeng Pintar Oase is catfish farming using the budikdamber system. Fish and fish products are major commodities in global food trade, and aquaculture has grown rapidly as a production system over the past two decades (Hasimuna *et al*., 2023). Budikdambers are a method of fish farming in buckets that aims to increase the efficiency of land and water use and allow for better water quality control, making them suitable for use in urban areas with limited land (Setyono *et al*., 2022). Catfish are highly adaptable to various environmental conditions, grow quickly, and are relatively easy to cultivate, making them suitable for aquaculture (Suraya *et al*., 2021). However, budikdamber has the potential to produce ammonia from fish food residues and feces. Ammonia is a toxic nitrogen compound that can reduce the quality of aquaculture water, damage gills, inhibit growth, and increase the risk of fish mortality if its concentration exceeds the safe threshold. Based on the SNI 6484.4:2014 water quality standard, the safe ammonia level is below 0.1 mg/L (Nitisuari *et al*., 2024).

An environmentally friendly alternative for reducing ammonia levels in fish farming systems is the use of aquatic plants as phytoremediation agents. In recent times, *Lemna minor* has been widely used as a phytoremediation agent for wastewater from aquaculture activities (Rifai *et al*., 2024). At Kampoeng Pintar Oase, *Lemna minor* is only used as supplementary feed for catfish and has not yet been used as an ammonia waste absorber. *Lemna minor* can affect the quality of fish farming water (Nurrasyida *et al*., 2024). Phytoremediation used of plants to reduce the amount, movement, or danger of pollutants in soil, groundwater, or other contaminated media (Savira & Fitrihidajati, 2024). Phytoremediation can be used as one of the efforts in managing fish farming wastewater by utilizing aquatic plants to absorb and reduce contaminants, including ammonia (Sukono *et al*., 2020). Phytoremediation has the advantages of cost efficiency, low energy consumption, minimal environmental impact, and supporting the sustainability of soil biological activities (Aziz *et al*., 2020).

Based on these conditions, this study aims to describe the effect of *Lemna minor* addition on ammonia level reduction in catfish pond systems, the lowest ammonia level achieved after *Lemna minor* addition, the impact of ammonia level reduction on catfish growth, and to assess the application of *Lemna minor* in catfish pond systems in supporting the achievement of SDG 2. The parameters measured include ammonia levels, total nitrogen, pH, temperature, and DO. Data analysis was conducted using quantitative descriptive methods. The research was conducted collaboratively with the community and the Lestari Bumi Abadi Foundation to obtain representative field data and support the implementation of applicable solutions. The results of this research can contribute scientifically and practically to the management of household-scale fish farming waste while supporting the achievement of SDG 2 (Zero Hunger) through increased productivity and sustainability of urban food systems.

METHOD

This study was conducted from September to November 2025 at Kampoeng Pintar Oase Tembok Gede, Surabaya. The study was conducted in two stages. The first stage was the creation of budikdamber media using the observation method. The second stage was experimental, namely the implementation of budikdamber (fish farming in buckets) for 21 days using two treatments, namely control (without *Lemna minor*) and treatment with *Lemna minor*, each of which was carried out three times. The parameters measured to strengthen the research results included ammonia levels, nitrogen levels, pH, temperature, and DO. The tools used in this study included used paint buckets, perforated iron wire, pH meters, thermometers, DO meters, markers, labels, cutters, scissors, soldering irons, HDPE bottles, and tissue cables. The materials used included catfish, *Lemna minor* plants, aquaculture media water, and fish food.

The study began with the preparation of tools and materials. *Lemna minor* plants were obtained from Taman Pondok Jati, Geluran, Taman, Sidoarjo, while catfish were obtained from local catfish farmers. The Budikdamber (fish farming in buckets) media was prepared, and the *Lemna minor* plants were acclimatized for 7 days. The *Lemna minor* used had fresh green leaves and was undamaged. The catfish used were 1 month old with a uniform weight of 20 grams and were in good health. The catfish adaptation process was carried out for 14 days with water drainage every 3 days. The implementation included treatment, maintenance of the budikdamber (fish farming in buckets) system, measurement of water quality parameters, and processing and analysis of research data. Sampling and water quality measurements were carried out every 7 days. The first sample was taken 7 days after water drainage following the adaptation period, which was considered day 0 and was the initial condition before the *Lemna minor* treatment was given. The second sample was considered day 7, and the third sample was considered day 14. In the treatment with *Lemna minor*, plants were added to the cultivation medium with a wet weight of 30 grams, while the control treatment did not include plants. The data obtained included ammonia, nitrogen, DO, pH, and water temperature levels. The measurement results were analyzed descriptively and quantitatively by comparing the results of the two treatments after testing the ammonia and total nitrogen levels at BSPJI Surabaya based on the SNI 6484.4:2014 water quality standards. The data were presented in tables and graphs to facilitate data processing and analysis.

RESULTS AND DISCUSSION

Based on the research results, the data obtained included water quality data, ammonia and total nitrogen levels, and catfish growth in the pond system with control treatment and *Lemna minor* addition. The measurement data is presented in tabular form to facilitate analysis and interpretation of the research results.

Table 1. Average Water Quality Measurements

Parameters	Treatments						SNI 6484.4:2014
	Control (1)	Control (2)	Control (3)	Addition of *Lemna minor* (1)	Addition of *Lemna minor* (2)	Addition of *Lemna minor* (3)	
pH	7.3	7.4	7.4	7.2	7.3	7.2	6.8-8
Temperature (°C)	31.5	31.5	31.5	31.5	31.5	31.5	25-30
DO (mg/L)	2.5	2.7	2.4	3.5	3.6	3.0	> 3

Water quality parameters showed varying values during the study. In accordance with the SNI 6484.4:2014 water quality standard, the pH values of both treatments still met the water quality standard. The water temperature tended to be outside the standard range, while the DO in the *Lemna minor* treatment tended to be higher than in the control treatment and met the standard. The temperature and DO of the control treatment were still within the tolerance limits of catfish (Table 1).

Table 2. Ammonia and Total Nitrogen Test

Time	Treatments				SNI 6484.4:2014
	Control		Addition of *Lemna minor*		
	Ammonia (mg/L)	Nitrogen (mg/L)	Ammonia (mg/L)	Nitrogen (mg/L)	Ammonia (mg/L)
Day-0	17.4	4.5	17.4	4.5	Maksimum 0.1
Day-7	0.14	6.6	0.72	16.6	
Day-14	7.6	26.9	3.9	8.7	

Ammonia levels changed during the study. Day 0 showed the initial conditions before the *Lemna minor* treatment was administered. On day 7, the *Lemna minor* treatment showed the lowest decrease in ammonia levels of 0.72 mg/L compared to day 14. On day 14, the ammonia level of the *Lemna minor* treatment was 3.9 mg/L, which was lower than the control treatment of 7.6 mg/L. However, this value still did not meet the water quality standards based on SNI 6484.4:2014 (Table 2).

Table 3. Average Weight Gain of Catfish

Time	Treatments							
	Control (1)	Control (2)	Control (3)	Average	Addition of *Lemna minor* (1)	Addition of *Lemna minor* (2)	Addition of *Lemna minor* (3)	Average
Weight on Day-0 (grams)	20	20	20	20	20	20	20	20
Weight on Day-21 (grams)	43	43	44	43	48	40	50	46

The weight gain of catfish treated with *Lemna minor* showed better growth compared to the control treatment. The *Lemna minor* treatment showed an average final weight of 46 g with a weight gain of 26 g, while the control treatment showed an average final weight of 43 g with a weight gain of 23 g (Table 3).

Budikdamber is a method of fish farming using buckets as containers that can be done in small areas with little water, capital, and is easy to implement by the community to meet protein nutritional needs from animals (Utami *et al*., 2024). Fish farming produces ammonia waste from food and feces and urine resulting from fish metabolism. High levels of ammonia can endanger the survival of catfish (Handayani *et al*., 2025). Ammonia levels in water can be influenced by water quality parameters. Water quality can be defined as the suitability of a body of water to support the life and growth of organisms, which is usually assessed through certain parameters. These parameters include pH, temperature, DO, TDS, and others (Tanody & Tasik, 2023).

The parameters in Table 1 involve water quality measurements of pH, temperature, and DO. The overall average pH of both treatments meets quality standards because it is still classified as stable according to SNI 6484.4:2014, which specifies a normal pH level of 6.8-8 (Nitisuari *et al*., 2024). The pH level can affect water quality because a pH level that is too low can increase the solubility of toxic metals. A pH level that is too high can increase the level of ammonia, which is also toxic to aquatic organisms (Nurwahyunani *et al*., 2024). The average temperature of both treatments was 31.5°C, which did not meet the SNI 6484.4:2014 quality standard of 25°C-30°C (Nitisuari *et aL*., 2024). The temperature increased due to extreme weather in the city of Surabaya, which directly affected the outdoor fish ponds even though they were under shade. According to Purnomo *et al*. (2024), temperature changes are influenced by natural factors and human activities. Natural factors include rain, high heat, and unpredictable weather, which have the potential to cause stress in fish. The overall average DO level of the Lemna minor treatment met the water quality standards based on SNI 6484.4:2014. The DO of the control treatment tended to be outside the SNI 6484.4:2014 quality standard, which was influenced by temperature; when the temperature increased, the dissolved oxygen decreased (Nurwahyunani *et al*., 2024). Fish compete for oxygen for respiration, coupled with the oxygen requirements of aerobic bacteria, which can reduce dissolved oxygen concentrations in the pond (Wicaksana, 2015 in Marsi *et al*., 2024).

The addition of *Lemna minor* was able to reduce ammonia levels lower than the control treatment. In Table 2, the lowest decrease in ammonia levels occurred on day 7, after 7 days of *Lemna minor* treatment, from an initial level of 17.4 mg/L to 0.72 mg/L, a reduction of 16.68 mg/L. On the 14th day after the addition of *Lemna minor*, the ammonia level decreased by 13.5 mg/L from the initial 17.4 mg/L to 3.9 mg/L. *Lemna minor* has been proven to be able to absorb ammonia well and can be used for water remediation with inorganic and organic content (Yulianto, 2020). The absorption mechanism carried out by plants can improve water quality while maintaining fish health (Alivia *et al*., 2024; Aditya *et al*., 2023; Imaniar *et al*., 2022). *Lemna minor* can assimilate ammonia and nitrate through its roots and leaves. The roots of *Lemna minor* carry organic and inorganic waste in the form of ions, which are then absorbed into the cytoplasm through biosorption. In the cytoplasm, organic waste undergoes enzymatic modification that converts compounds into less complex molecules, while inorganic waste in the cytoplasm undergoes direct genetic transfer or conjugation, which then enters the vacuole surrounded by the primary cell wall, thereby reducing dissolved nitrogen compounds (Nurrasyida *et al*., 2024).

Ammonia absorption from day 7 to day 14 increased because *Lemna minor* experienced a decrease in nutrient absorption effectiveness. According to previous research by Puspitasari & Irawanto (2016) in Nurrasyida *et al*. (2024), nutrient absorption by *Lemna minor* plants is known to be most effective in the early stages of growth, especially in the first two weeks. On the 14th day of the study, many *Lemna minor* plants died due to their short lifespan, so it was necessary to add more plants periodically to keep the ammonia levels in the catfish pond low. The control treatment without *Lemna minor* experienced a decrease in ammonia levels due to three processes, namely volatilization, ammonification, and immobilization. Volatilization occurs due to the evaporation of ammonia into the air in the form of gas. This mechanism is one of the main causes of reduced ammonia concentration, especially in open environments exposed to sunlight. The fish ponds are located outdoors, so they are directly exposed to sunlight. The next process is ammonification, which is the process of breaking down organic nitrogen into ammonia by microorganisms in water or soil. Microorganisms can also perform immobilization by absorbing ammonia for metabolic needs, thereby reducing ammonia levels. The processes of ammonification and immobilization can work simultaneously through chemical changes and the biological activity of microorganisms (Kholif & Sugito, 2020).

Even though ammonia levels decrease, nitrogen can still accumulate in the pond. Ammonia is part of the total nitrogen in the water. A decrease in ammonia levels is not always followed by a decrease in total nitrogen because ammonia can be transformed into other forms of nitrogen such as nitrite and nitrate through the nitrification process. The non-ionized form of TAN (NH_3) is toxic and can damage gills, stunt growth, and cause death in fish (Sinha & Banerjee, 2025). Based on Table 2, the treatment with *Lemna minor* showed lower total nitrogen levels than the control on day 14. This indicates that nitrogen not only undergoes a change in form but is also absorbed and assimilated by *Lemna minor*, thereby reducing nitrogen accumulation in the water. Ammonia in water consists of un-ionized ammonia (NH_3) and ionized ammonium (NH_4^+), which are collectively referred to as Total Ammonia Nitrogen (TAN). Ammonia in the form of NH_3 is the most toxic form for fish, and its amount is influenced by pH and water temperature. The nitrification process, which converts ammonia into nitrite and nitrate, is influenced by environmental conditions, particularly pH, dissolved oxygen, and alkalinity. Overall, the decrease in total nitrogen levels in the *Lemna minor* treatment indicates that this plant can absorb dissolved nitrogen and improve water quality in catfish pond systems, thereby potentially supporting fish growth (Wahyuningsih & Gitarama, 2020).

Growth is an increase in the weight or length of fish within a certain period of time, which is influenced by the number of fish, food availability, age, temperature, and body size of the fish (Seran & Salu, 2024). Based on Table 3, the decrease in ammonia levels with the addition of *Lemna minor* shows a correlation with catfish growth, with an average weight gain of 46 grams. Within a period of 21 days, the fish's weight gain was inhibited because the catfish could not adapt well to the breeding tank, resulting in suboptimal growth. Inadequate oxygen levels, cramped space, minimal oxygen supply from outside or from water flow, and high ammonia levels cause the energy that should be used by fish for growth and development to be used instead to survive in a poor environment (Setyani *et al*., 2021). Ammonia levels above the quality standard can cause stress in fish. Stress in fish can interfere with immune and metabolic functions (Guo *et al*., 2025). The decline in water quality during the study can also affect the weight gain of catfish due to the accumulation of feces from metabolism. The accumulation of these substances causes discoloration and an unpleasant odor in the water, which has a negative impact on farmed fish. Ammonia that is not immediately decomposed by bacteria over a long period of time can inhibit fish growth, so regular renewal of the aquaculture water is necessary (Seran & Salu, 2024).

Catfish can continue to live because their ability to adapt is very good. The catfish respiratory organs help it survive in relatively extreme water conditions (Nchegang *et al*., 2024). The catfish's respiratory system consists of gills and additional arborescent respiratory organs that enable it to utilize oxygen from the air. This ability allows catfish to survive even in waters with low oxygen levels. In addition, the survival rate of fish can be influenced by internal and external factors. Internal factors include the age of the fish and its ability to adapt to the environment. Meanwhile, external factors include abiotic conditions such as food availability and the quality of the fish's living environment (Pratopo & Thoriq, 2021). The quality of the living environment based on physical, chemical, and biological factors includes temperature, light intensity, pH, dissolved oxygen, nutrient or organic content, and microorganism activity (Yusoff *et al*., 2024). pH, temperature, and dissolved oxygen levels are interrelated in the respiration and metabolic rate processes in fish (Nurwahyunani *et al*., 2024).

The application of *Lemna minor* plants in catfish pond farming systems shows that the use of *Lemna minor* can support sustainable food security and the achievement of SDG 2 (Zero Hunger). SDG 2 targets Zero Hunger through sustainable food security. Based on previous research by Battersby in 2015, it was revealed that the weak integration of urbanization aspects is a major factor in increasing food and changing nutritional patterns, thereby hindering the achievement of SDG 2 (Ikudayisi & Adejumo, 2025). Mulyaningsih & Astuti (2022) stated that one important approach to achieving SDG 2 in Indonesia is a food diversification policy based on local potential, especially to reduce dependence on certain commodities. Sustainable Development Goal (SDG) number 2 targets the elimination of hunger and the improvement of sustainable food security. Ammonia waste management in fish farming systems is crucial to ensure that food production remains safe, healthy, and sustainable without damaging the environment. Phytoremediation supports this aspect by reducing waste pollution, thereby effectively maintaining water quality and fish health (Naghiesa *et al*., 2024).

CONCLUSION

Based on the research, it can be concluded that *Lemna minor* shows the ability to reduce ammonia levels in catfish pond systems when *Lemna minor* is administered, with a greater reduction in ammonia levels compared to the control treatment. The lowest ammonia level achieved after administering Lemna minor in the pond system was 0.72 mg/L on the 7th day. The reduction in ammonia levels with the addition of *Lemna minor* was associated with the growth of catfish, with an average weight gain of 46 grams. The application of *Lemna minor* plants in catfish aquaculture systems shows that the use of *Lemna minor* can support sustainable food security and the achievement of SDG 2 (Zero Hunger).

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