Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Bold)

The Effect of Salinity on Osmoregulation Physiology of Survival and Respiration Rate of Tilapia Fish (*Oreochromis niloticus*)

I Wayan Merta*, Kusmiyati

Biology Education Study Program, Faculty of Teacher Training and Education, University of Mataram, Mataram, Indonesia
*e-mail: wayanmerta.fkip@unram.ac.id

Received: March 10, 2025. Accepted: May 29, 2025. Published: May 30, 2025

Abstract: Osmoregulation is a process used by fish to maintain the balance of water and ion levels in the body, so that salinity becomes a limiting factor for the life of Tilapia fish. This study aims to determine the effect of salinity on osmoregulation, physiological survival and respiration rate of Tilapia fish (*Oreochromis niloticus*). This research design used an experimental method with a Completely Randomized Design (CRD) approach. This research design involved four different treatment levels and was carried out with five repetitions for each treatment. Each treatment was designed to test the effect of a particular variable on the observed parameters, with repetitions aimed at ensuring consistency of results. P1: Control (No Filter). P2: Salinity 5 ppt. P3: Salinity 10 ppt. P4: Salinity 15 ppt. The activity of tilapia in each salinity medium was observed to determine changes in behavior after the fish were inserted into the salinity medium. Physiological responses were observed, and the respiration of tilapia through operculum movements in each salinity medium was calculated after 5 minutes of treatment for 1 minute. Survival was calculated after 5 minutes of treatment until the tilapia died. Data were analyzed using one-way ANOVA, with a significance level of 5%. If there was a significant difference, it was continued with the LSD test (Least Significant Difference). Based on the ANOVA test, the Sig. value obtained was .000 (<0.05), indicating that there is an effect of salinity on the physiological osmoregulation of tilapia survival (*Oreochromis niloticus*). Based on the results of the Multiple 12 Comparisons LSD test, it can be seen that all differences between treatment groups are significant with a 95% confidence level ($p < 0.05$). Based on data analysis and discussion, the study concluded that salinity has a significant effect on the respiratory rate of tilapia (*Oreochromis niloticus*), where increasing salt levels cause an increase in the frequency of operculum movements in response to osmotic stress. The main factors affecting the survival of tilapia to salinity differences are the ability to osmoregulate, which is increasingly inhibited as salt levels increase, as well as the duration of exposure to more hypertonic environmental conditions.

Keywords: Physiological Osmoregulation; Survival, Respiratory Rate; Tilapia (*Oreochromis niloticus*).

Introduction

Tilapia (*Oreochromis niloticus*) is one of the freshwater fishery commodities that has long been known and cultivated by the wider community. This fish is the main choice because of its high nutritional content and is almost equivalent to other freshwater fish [1]. In addition, Tilapia has various advantages such as high adaptability, relatively fast growth, large body size, and resistance to changes in environmental conditions [2]. Tilapia can live in various types of waters, from rivers, lakes, swamps, to narrow ponds, including tarpaulin ponds, which are currently an economical cultivation alternative because they are easy to move, low cost, and do not cause odor to the fish being raised [3].

Although Tilapia is known as a species that is tolerant of environmental fluctuations, the success of cultivation still depends heavily on water quality management. Poor water quality can reduce growth rates, cause physiological stress, and even death in fish. Therefore, management of physical and chemical parameters of water, such as temperature, pH, dissolved oxygen, and ammonia, is very crucial in ensuring the survival and growth of Tilapia. Although this fish can survive in various conditions, including in lowland areas with brackish water or in highlands with low temperatures, special attention is still needed to the quality of its living media [4].

Water, as the main medium in fish cultivation, plays a vital role in supporting the metabolism, growth, and reproduction of fish. As a natural resource, water is not only important for humans, but also becomes the main habitat for aquatic organisms such as fish. Therefore, water quality must meet certain requirements in order to optimally support fish life. Changes in water quality that are not appropriate can have a direct impact on fish health and cultivation production results. Based on this background, it is necessary to conduct research on the physical and chemical parameters of pond water and their effects on the growth of Tilapia as a basis for sustainable and productive cultivation management.

How to Cite:
I. W. Merta and K. Kusmiyati, "The Effect of Salinity on Osmoregulation Physiology of Survival and Respiration Rate of Tilapia Fish (Oreochromis niloticus)", *J. Pijar.MIPA*, vol. 20, no. 3, pp. 580–584, May 2025. https://doi.org/10.29303/jpm.v20i3.5043

Research Materials and Methods

Tools and Materials

Tools and materials: this research uses tools: stationery, 2 liter plastic bucket, *a mobile phone*, a *pH* meter, a water hose, a salt spoon, and a stopwatch. The materials are 1 liter of water, salt, and tilapia fish (*Oreochromis niloticus*).

Research Design and Data Analysis Techniques

Time and Place of Research This research was conducted on Thursday, February 20, 2025, starting at 15.00 WITA at Jempong Baru Village, Sekarbela District, Mataram City, West Nusa Tenggara Province.

The observation design of this study used an experimental method with a Completely Randomized Design (CRD) approach. This study design involved four different treatment levels and was carried out with five repetitions for each treatment. This approach was chosen because it was able to minimize the influence of external factors that could affect the results of the study, thus providing more valid and reliable results. Each treatment was designed to test the effect of certain variables on the observed parameters, with repetitions aimed at ensuring consistency of the results. P1: Control (No Filter). P2: Salinity 5 ppt. P3: Salinity 10 ppt. P4: Salinity 15 ppt. The activity of tilapia in each salinity medium was observed to determine changes in behavior after the fish were inserted into the salinity medium. Physiological responses were observed, and the respiration of tilapia through operculum movements in each salinity medium was calculated after 5 minutes of treatment for 1 minute. Survival was calculated after 5 minutes of treatment until the tilapia died. Data were analyzed using one-way ANOVA, with a significance level of 5%. If there was a significant difference, it was continued with the LSD test (*Least Significant Difference*) [5], [6]..

Results and Discussion

Tilapia is a type of fish that originates from the waters of the Nile River Valley in Africa, and was first brought to Indonesia in 1969, 1990, and 1994, respectively, from Taiwan, Thailand, and the Philippines. Tilapia is included in the Phylum Chordata, Class Pisces, Subclass Teleostei, Order Percomorphi, Suborder Percoidea, Family Cichlidae, Genus Oreochromis, with Species *Oreochromis Sp*. [7]. Osmoregulation is a process used by tilapia to maintain the balance of water and ion levels in the body [8]. Salinity is a limiting factor for the life of aquatic animals [9]. The results of research on the effect of salinity on osmoregulation, physiological survival and respiratory rate of tilapia (*Oreochromis niloticus*) show that variations in salt content in the maintenance medium have a significant impact on the physiological condition of the fish. Based on Table 2, it can be seen that in the treatment with 15g of salt, tilapia fish died more quickly when compared to the other treatment groups.

Table 1. Observation of Tilapia Fish Breathing (*Oreochromis niloticus*) Time Unit Minutes

Treatment	Fish 1	Fish 2	Fish 3	Fish 4	Fish 5	Relate
Control	109	108.1	98.3	94.8	104.7	102.98
5g Garam	90	89	100.1	124.2	102.2	101.1
10g Garam	127.4	135.3	140.5	113	157.4	134.72
15g Garam	126.8	113.3	134.8	125.8	131.3	126.4

Table 2. Observations on the Survival of Tilapia Fish (*Oreochromis niloticus*)

Treatment	Time (Hour)					
	Fish 1	Fish 2	Fish 3	Fish 4	Fish 5	Relate
Control	74	74	71	73	70	72,4
5g Garam	65	60	61	63	64	62,6
10g Garam	41	39	38	37	35	38
15g Garam	18	15	14	17	16	16

Table 3. Results of One-Way Analysis of Variance of Tilapia Survival in Minutes

Groups	Sum of Squares	df	Mean Square	F	Say
Between Groups	9651.350	3	3217.117	852.216	.000
Within Groups	60.400	16	3.775		
Total	9711.750	19			

Table 4. LSD Test Results (*Least Significant Difference*)

(I) Treatment Group		Mean Difference (I-J)	Std. Error	Say.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	5g Garam	9.800*	1.229	.000	7.20	12.40
	10g Garam	34.400*	1.229	.000	31.80	37.00
	15g Garam	56.400*	1.229	.000	53.80	59.00

5g Garam	Control	-9.800*	1.229	.000	-12.40	-7.20
	10g Garam	24.600*	1.229	.000	22.00	27.20
	15g Garam	46.600*	1.229	.000	44.00	49.20
10g Garam	Control	-34.400*	1.229	.000	-37.00	-31.80
	5g Garam	-24.600*	1.229	.000	-27.20	-22.00
	15g Garam	22.000*	1.229	.000	19.40	24.60
15g Garam	Control	-56.400*	1.229	.000	-59.00	-53.80
	5g Garam	-46.600*	1.229	.000	-49.20	-44.00
	10g Garam	-22.000*	1.229	.000	-24.60	-19.40

*. The mean difference is significant at the 0.05 level.
The results of the LSD test showed that all differences between treatment groups were significant at the 95% confidence level ($p < 0.05$).

Based on Table 1, observations of tilapia fish respiration show changes in the number of operculum movements at various salinity levels. In control conditions (0 ppt), the fish's respiratory rate was relatively stable with an average of 102.98 operculum movements per minute. When the fish were placed in a medium with a salinity of 5 ppt, there was a slight decrease in the respiratory rate in some individuals, with an average of 101.1 operculum movements per minute. The difference in respiratory rate between the two treatments was not too significant, in line with research [10] stating that 5 ppt salinity can be tolerated well by tilapia fish. However, in the treatment with a salinity of 10 ppt, the respiratory rate increased drastically to an average of 134.72 operculum movements per minute. This increase indicates higher osmotic stress because the fish must adapt to higher salt levels. At the highest salinity, namely 15 ppt, the respiratory rate remained high with an average of 126.4 operculum movements per minute, but there was a greater fluctuation between individuals. This shows that increasing salinity affects the osmoregulation mechanism of Tilapia fish, causing them to increase their respiratory rate as a form of compensation for changes in ion balance in their bodies. Furthermore, [11], [12] said that gills are the main organs in fish osmoregulation. Gills not only function for gas exchange, but also in ion regulation through active transport mechanisms. In high salinity conditions, chloride cells in the gills play a role in releasing sodium and chloride ions to avoid excess salt accumulation. While in low salinity conditions, gills absorb more ions to maintain electrolyte balance.

In Table 2 on the survival of Tilapia fish to salinity, it shows that the higher the salt content in the media, the lower the survival of Tilapia fish. In the control treatment (0 ppt), fish were able to survive for an average of 72.4 hours. When salinity increased to 5 ppt, fish survival began to decrease, with an average of 62.6 hours. A sharper decline occurred at a salinity of 10 ppt, where fish were only able to survive for an average of 38 hours. In the treatment with the highest salinity, namely 15 ppt, fish survival dropped drastically to only about 16 hours. These results indicate that Tilapia fish have a tolerance limit to certain salinity, and the higher the salt content, the more difficult it is for fish to maintain their physiological balance, thus shortening their lifespan. The results of this study are also supported by research [13], [14], the higher the salinity value, the higher the mortality rate of Tilapia fish. An increase in salinity can cause oxygen solubility to decrease, thus causing the death of Tilapia fish. Table 2 also shows the survival time of tilapia fish, showing variation in individual resistance to different salinities. In the control treatment (0 ppt), all fish were able to survive for 70-74 hours. At a salinity of 5 ppt, fish survival began to decline with a time range of 60-65 hours. A drastic decrease occurred at a salinity of 10 ppt, where the fish only survived for around 35-41 hours. Treatment with a salinity of 15 ppt showed the lowest results, with fish survival of only around 14-18 hours. This time variation shows that although tilapia fish have tolerance to salinity, the higher the salt content, the greater the osmotic pressure, which causes faster death. The ANOVA test in Table 3 obtained a Sig. value of .000 (<0.05), indicating that there is an effect of salinity on the physiological osmoregulation of tilapia fish survival (*Oreochromis niloticus*). Based on the results of the Multiple 12 Comparisons LSD test in Table 4, it can be seen that all differences between treatment groups are significant with a 95% confidence level ($p < 0.05$). This indicates that each increase in salinity has a real effect on the survival of tilapia. The significant difference between the control and the 5 ppt treatment shows that even relatively low salt levels have begun to affect the survival of the fish. The difference is even greater when compared to the 10 ppt and 15 ppt treatments, indicating that increasing salinity directly shortens the survival of tilapia significantly. Based on the results obtained, this finding confirms that the higher the salinity level, the lower the survival of tilapia, which can be caused by increased osmotic pressure that affects the physiological balance of the fish. Thus, this study confirms that the salt content in water has a real impact on the survival of tilapia, and each increase in salinity causes significant changes in the survival of the fish.

In addition, it can be said that salinity has a significant effect on the physiological response of fish, both in terms of increasing the respiratory rate in response to osmotic stress and in decreasing survival due to ion imbalance in body fluid regulation. Thus, this study confirms that tilapia has tolerance to changes in salinity to a certain extent, but at higher levels, fish survival decreases significantly. This finding provides important insights into tilapia cultivation, especially in selecting the optimal maintenance environment so that fish can grow and survive well. In line with research by [15], [16], which stated that the treatment of different water salinity significantly affected the growth and survival rate of tilapia seeds, it is known that salinity concentrations of 5 ppt and 10 ppt can

be well tolerated by tilapia seeds. However, sudden salinity can cause stress that leads to the death of tilapia seeds, so gradual adaptation to changes in salinity is an important factor in maintaining this fish. Research [17] stated that fish deaths that occurred in each treatment were influenced by several factors, including salinity. The higher the salinity value, the higher the mortality rate of tilapia fish seeds, because an increase in salinity can cause oxygen solubility to decrease, thus causing death in tilapia fish.

There is also a factor of the size of the Tilapia fish seed, which also affects the ability to survive, apart from the genetic characteristics and condition of the fish when they are put into the salinity media. This is also related to the death of Tilapia fish that occurred in treatment 2 (15 - 20 ppt) and treatment 3 (20 - 25 ppt), which experienced many deaths. The higher the salinity value, the greater the difference in osmotic pressure between the body and its environment. The impact of the high salinity value is that Tilapia fish need more energy to carry out the osmoregulation process as an effort to stabilize the body's condition to new environmental conditions. The process of conditioning Tilapia fish is to increase the salinity gradually every day until it does not exceed 5 ppt at each stage of salinity increase, or commonly called acclimatisation [18]. While the conditioning process in this study did not go through a gradual salinity increase process, which had an impact on death. Similar to the results obtained by [19-20], which stated that tilapia fish can survive well up to a salinity of 5 ppt at fish sizes of 3–5 cm and 5–8 cm. However, at higher salinities, such as 10 ppt and 15 ppt, tilapia fish began to experience significant negative impacts. At a salinity of 10 ppt, tilapia fish began to die after 2 hours and experienced total death after 3 hours. Meanwhile, at the highest salinity, namely 15 ppt, tilapia fish experienced total death in just 1 hour. This shows that tilapia fish have a tolerance limit to certain salinities, and exposure to higher salinity levels for a short time can cause physiological stress, leading to death.

Conclusion

Based on the research and results obtained, it can be concluded that salinity has a significant effect on the respiratory rate of tilapia fish (*Oreochromis niloticus*), where increasing salt levels cause an increase in the frequency of operculum movements in response to osmotic stress. The main factors affecting the survival of Tilapia due to differences in salinity are the ability to osmoregulate, which is increasingly inhibited as salt levels increase, as well as the duration of exposure to more hypertonic environmental conditions. In addition, there are significant behavioural changes in Tilapia due to exposure to different salinities, where at higher salt levels, fish show signs of stress such as increased respiratory activity, decreased movement, and ultimately die more quickly compared to fish in freshwater or low salinity conditions.

Author's Contribution

I Wayan Merta: designed the study, conducted the experiments, and wrote the initial draft of the manuscript. Kusmiyati: contributed to the collection, analysis of data, validation of results, and critical review of the content of the manuscript until the final stage.

Aknowledgement

We express our deepest gratitude to the University of Mataram for providing research facilities and support during the research. Special thanks are also extended to the laboratory staff for their assistance during the experimental process.

Reference

[1] S. S. Monalisa and I. Minggawati, "Kualitas Air Yang Mempengaruhi Pertumbuhan Ikan Nila (Oreochromis sp.) di Kolam Beton dan Terpal," *Journal of Tropical Fisheries*, vol. 5, no. 2, pp. 526–530, 2010.

[2] M. Pramleonita, N. Yuliani, R. Arizal, and S. E. Wardoyo, "Parameter Fisika dan Kimia Air Kolam Ikan Nila Hitam (Oreochromis niloticus)," *Jurnal Sains Natural*, vol. 8, no. 1, pp. 24–34, 2018, doi: 10.31938/jsn.v8i1.107.

[3] F. P. Pane, D. Arfiati, and F. J. Apriliyanti, "Respon Fisiologi Ikan Terhadap Lingkungan Hidupnya: Physiological Response Of Fish To Its Environment," *Jurnal Aquatik*, vol. 6, no. 2, 2023, doi: 10.35508/aquatik.v6i2.12921.

[4] K. Amri and Khaituman, *Budi Daya Ikan Nila*, Jakarta Selatan: P Agromedia Pustaka, 2020.

[5] R. G. D. Steel and J. H. Torrie, *Prinsip dan Prosedur Statistika: Suatu Pendekatan Biometrik*, Ed. 2, Jakarta: Gramedia Pustaka Utama, 1993.

[6] Sudjana, *Metode Statistik*, Ed. 5, Bandung: Tarsito, 1992.

[7] M. Y. Arifin, "Pertumbuhan dan Survival Rate Ikan Nila (Oreochromis sp.) Strain Merah dan Strain Hitam yang Dipelihara Pada Media Bersalinitas," *Jurnal Ilmiah Universitas Batanghari Jambi*, vol. 16, no. 1, pp. 159–166, 2017.

[8] D. H. Evans, P. M. Piermarini, and K. P. Choe, "The Multifunctional Fish Gill: Dominant Site of Gas Exchange, Osmoregulation, Acid-Base Regulation, and Excretion of Nitrogenous Waste," *Physiological Reviews*, vol. 85, no. 1, pp. 97–177, 2005, doi: 10.1152/physrev.00050.2003.

[9] W. S. Marshall and M. Grosell, "Ion Transport, Osmoregulation, and Acid-Base Balance," in *The Physiology of Fishes*, 3rd ed., pp. 177–230, 2006.

[10] I. Ferman, A. Saimima, and S. La Puasa, "Uji Coba Pemeliharaan Ikan Nila (Oreocromis niloticus) Pada Media Salinitas yang Berbeda," *Jurnal Ilmu Perikanan dan Masyarakat Pesisir*, vol. 11, no. 2, pp. 21–30, 2024.

[11] R. Astuti, N. Marlian, F. Lubis, L. R. Putri, M. Haikal, and H. Nufus, "Adaptasi Fisiologi Dan Tingkah Laku Organisme Akuatik Terhadap Perubahan Salinitas," *Jurnal Of Aceh Aquatic Sciences*, vol. 8, no. 2, pp. 69–76, 2024.

[12] T. Rohman, Y. T. Wulandari, W. I. Leksani, and D. Chandrawati, "Pengaruh Perbedaan Salinitas Air Terhadap Survival Rate dan Respon Fisiologis Benih Ikan Nila (Oreochromis niloticus)," in *Prosiding SNPBS*, pp. 114–123, 2017. ISSN: 2527-533X.

[13] F. F. Muhsoni, "Laju Pertumbuhan Dan Kelangsungan Hidup Ikan Nila (Oreochromis niloticus) Pada Salinitas Yang Berbeda," *Juvenil: Jurnal Ilmiah Kelautan dan Perikanan*, vol. 2, no. 3, pp. 166–175, 2021, doi: 10.21107/juvenil.v2i3.11271.

[14] A. S. Fitri, "Analisis Kelulushidupan dan Pertumbuhan Benih Ikan Nila Larasati (Oreochromis niloticus) F5 D30-D70 Pada Berbagai Salinitas," *Jurnal Of Aquaculture Management and Technology*, vol. 1, no. 1, pp. 18–32, 2012.

[15] M. F. Shafry and I. Yuniar, "Pengaruh Perbedaan Salinitas Terhadap Kelangsungan Hidup Dan Pertumbuhan Benih Ikan Nila Merah (Oreocromis Sp)," *Fisheries: Jurnal Perikanan Dan Ilmu Kelautan*, vol. 4, no. 1, pp. 19–27, 2022, doi: 10.30649/fisheries.v4i1.61.

[16] A. M. Akbar, A. Jayanthi, S. Fajri, Kharunnisa, S. A. Zahra, M. T. Sari, and Mardiah, "The Influence Of Different Media On The Physiological Response Of Nila Fish (Oreochromis niloticus)," *Jurnal Biologi Tropis*, vol. 23, no. 2, pp. 187–193, 2023, doi: 10.29303/jbt.v23i2.6135.

[17] A. Yulan and A. A. Gemaputri, "Tingkat Kelangsungan Hidup Benih Ikan Nila Gift (Oreochromis niloticus) Pada Salinitas Yang Berbeda," *Jurnal Perikanan Universitas Gadjah Mada*, vol. 15, no. 2, pp. 78–82, 2013.

[18] I. M. Chotiba, "Pengaruh Salinitas Terhadap Kelangsungan Hidup Dan Pertumbuhan Benih Ikan Nila Nirwana (Oreochromis niloticus)," Skripsi, Fakultas Perikanan dan Ilmu Kelautan, Universitas Padjajaran, Jatinagor, 2013.

[19] M. H. F. Ath-thar and R. Gustiano, "Riset Pengembangan Pra-Budidaya Ikan Nila Best (Oreochromis niloticus) Di Media Salinitas," *Media Akuakultur*, vol. 5, no. 1, pp. 1–9, 2010, doi: 10.15578/ma.5.1.2010.1-9.

[20] E. T. Wahyuni, "Pengaruh Perbedaan Salinitas Air terhadap Tingkat Kelangsungan Hidup Benih Ikan Nila Merah (Oreochromis niloticus)," *Jurnal Perikanan*, vol. 1, no. 1, pp. 87–98, 2005.