E-ISSN 2618-6365 Vol. 7 Issue 1 2024

# AQUATIC RESEARCH

http://aquatres.scientificwebjournals.com

AQUATIC RESEARCH
E-ISSN 2618-6365



**Publisher Nuray Erkan Özden**

**Adress:** Abdi Bey Sok. KentPlus Kadıköy Sitesi B Blok No: 24B D. 435 Kadıköy/İstanbul, Türkiye
**E-mail:** swj@scientificwebjournals.com
**for submission instructions, subscription, and all other information visits**
http://aquatres.scientificwebjournals.com

AQUATIC RESEARCH
E-ISSN 2618-6365

# Aims and Scope

## AQUATIC RESEARCH

Abbreviation: **Aquat Res**

**e-ISSN: 2618-6365**

**Journal published in one volume of four issues per year by**

**http://aquatres.scientificwebjournals.com web page**

"**Aquatic Research**" journal aims to contribute to the literature by publishing manuscripts at the highest scientific level in all marine and aquatic sciences fields. The journal publishes original research and reviews articles prepared by ethical guidelines. The publication language of the journal is English or Turkish, and continued publication since 2018.

Aquatic Biology, Aquatic Ecology, Aquatic Environment and Pollutants, Aquaculture, Conservation and Management of Aquatic Source, Economics and Management of Fisheries, Fish Diseases and Health, Fisheries Resources and Management, Genetics of Aquatic Organisms, Limnology, Maritime Sciences, Marine Accidents, Marine Navigation, and Safety, Marine and Coastal Ecology, Oceanography, Seafood Processing, and Quality Control, Seafood Safety Systems, Sustainability in Marine and Freshwater Systems The target audience of the journal includes specialists and professionals working and interested in all disciplines of marine and aquatic sciences.

Manuscripts submitted to the "**Aquatic Research**" journal will go through a double-masked peer-review process. Each submission will be reviewed by at least two external, independent peer reviewers who are experts in their fields to ensure an unbiased evaluation process. The editorial board will invite an external and independent editor to manage the evaluation processes of manuscripts submitted by editors or by the editorial board members of the journal. Our journal will be published quarterly in English or Turkish language.

The journal's target audience includes specialists and professionals working and interested in all disciplines of marine and aquatic Sciences.

The editorial and publication processes of the journal are shaped by the guidelines of the International Committee of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME), Council of Science Editors (CSE), Committee on Publication Ethics (COPE), European Association of Science Editors (EASE), and National Information Standards Organization (NISO). The journal conforms to the principles of

Transparency and Best Practice in Scholarly Publishing (doaj.org/bestpractice).

"**Aquatic Research**" journal is indexed in TR Dizin, Clarivate Zoological Record, FAO/AGRIS, SciLit, and Bielefeld Academic Search Engine (BASE).

Processing and publication are free of charge with the journal. No fees are requested from the authors at any point throughout the evaluation and publication process. All manuscripts must be submitted via the online submission system, which is available at

**http://dergipark.gov.tr/journal/2277/submission/start**

The journal guidelines, technical information, and the required forms are available on the journal's web page.

Statements or opinions expressed in the manuscripts published in the journal reflect the views of the author(s) and not the opinions of the publisher, ScientificWebJournals Web Portal, editors, editorial board, and/or publisher; the editors, editorial board, and publisher disclaim any responsibility or liability for such materials.

All published content is available online, free of charge, at **http://aquatres.scientificwebjournals.com**.


**Editor in Chief:**

Prof. Dr. Nuray ERKAN

**Address:** Istanbul University, Faculty of Aquatic Sciences, Department of Food Safety, Kalenderhane Mah. 16 Mart Şehitleri Cad. No: 2, 34134 Fatih/Istanbul, Türkiye

**E-mail:** nurerkan@istanbul.edu.tr

AQUATIC RESEARCH
E-ISSN 2618-6365

Vol. 7 Issue 1 Page 1-50 (2024)

# Content

## Research Articles

AQUATIC RESEARCH

E-ISSN 2618-6365

Aquatic Research 7(1), 1-7 (2024) • https://doi.org/10.3153/AR24001 *Research Article*

# The efficacy of salt treatment for *Dactylogyrus extensus* (Monogenea) infection in Carp (*Cyprinus carpio*)

**Hijran YAVUZCAN YILDIZ**

**Cite this article as:**
Yavuzcan Yıldız, H. (2024). The efficacy of salt treatment for *Dactylogryrus extensus* (Monogenea) infection in Carp (*Cyrprinus carpio*). *Aquatic Research*, 7(1), 1-7. https://doi.org/10.3153/AR24001

Ankara University, Faculty of Agriculture, Department of Fisheries and Aquaculture, Ankara, Türkiye

**ORCID IDs of the author(s):**
H.Y.Y. 0000-0001-6567-7467

**ABSTRACT**

Salt is widely recommended as a cost-effective and readily available compound against freshwater fish parasites in aquaculture; however, a limited number of studies provide scientific evidence regarding the efficacy of salt use despite its frequent use as an anti-parasitic in fish culture. *Dactylogyrus* is a severe gill parasite, causing considerable losses in freshwater aquaculture. The current study aimed to evaluate the anti-parasitic efficacy of salt against *Dactylogyrus extensus* in *Cyprinus carpio*. *In vitro,* mortality of *D. extensus* showed time- and concentration-dependent patterns. *In vivo,* the anti-parasitic effectiveness of salt to *D. extensus* was assessed at 23.56% after exposure to salt at a concentration of 1.25 g/L for 10 min. Anti-parasitic efficacy of salt in short-term application in carp can be categorised between slight and mild against monogenean, *D. extensus*.

**Keywords:** Carp, *Cyprinus carpio*, Salt, Antiparasitic efficacy, *Dactylogyrus extensus*

**Submitted:** 01.08.2023
**Revision requested:** 29.08.2023
**Last revision received:** 26.09.2023
**Accepted:** 28.09.2023
**Published online:** 16.11.2023

**Correspondence:**
Hijran YAVUZCAN YILDIZ
**E-mail:** yavuzcan@ankara.edu.tr



**Available online at**
http://aquatres.scientificwebjournals.com

## Introduction

Intensive aquaculture has provided suitable conditions for spreading parasitic diseases because of the negative interaction among the parasite, host and water environment (Jerônimo et al., 2012). A higher incidence of parasites is one of the predisposing factors in developing disease outbreaks, leading to increased risk of sustainable aquaculture. Parasites have adverse effects on cultured fish species, resulting in high mortality rates, retardation in growth and impaired welfare. Parasitic infections also increase secondary bacterial and viral diseases by acting as a vector to transmit other pathogens (Kotob et al., 2016).

Monogenean helminth parasites are multicellular metazoan organisms causing considerable losses in marine and freshwater fish. The frequent incidence of Monogenean *Dactylogyrus* species represents a significant problem for fish culture. The direct life cycle of *Dactylogyrus* species enables them to reproduce quickly and reach higher prevalence and density in the gills of fish (Hu et al., 2017; Hutson et al., 2018). Pathologies such as excess mucous secretion, epithelial damage, haemorrhages, osmotic problems, and atrophy of the gills are common in fish heavily infected by *Dactylogyrus* species (Whittington, 2005; Reed et al., 2012). The failure to maintain the gill epithelium's appropriate functioning and the subsequent respiration problems ended in fish death (Pimentel-Acosta et al., 2019).

Drugs and various chemicals to control the parasites of fish, such as acriflavine, hydrogen peroxide, formalin, potassium permanganate, copper sulfate, acetic acid and praziquantel, have been used in practice (Buchmann et al., 2004; Fajer-Ávila et al., 2007; Zhang et al., 2014). Many chemicals are subjected to limitations for their use in fish production because of the risks to fish, the aquatic environment, and final consumers (Lieke et al., 2020). There is no specific regulation about salt use in aquaculture operations. Salt, or sodium chloride in its chemical form, is a compound of low regulatory priority, widely and traditionally used as an anti-parasitic agent to control parasites in freshwater fish culture (Burka et al., 1997; Velasco-Santamaría & Cruz-Casallas, 2008; Kayis et al., 2009; García-Magaña et al., 2019). Salt treatment is considered convenient and cost-effective in the practice of aquaculture. However, there is little information on the anti-parasitic efficacy of salt against freshwater parasites and its possible effects on fish health. Immersion treatments of various substances may have remarkable, unexpected effects on gill tissue, causing subsequent problems in overall fish health (Diggles et al., 2017). It is noted that the exposure of stenohaline carp to the salt solution caused adverse effects on fish physiology, resulting in stress-induced additive energy requirements and, eventually, a reduction in energy stores (De Boeck et al., 2000). The response of parasites to salt treatment is affected by parasite species, exposure time and concentration (Schelkle et al., 2011; García-Magaña et al., 2019). The pathogen and fish-specific concentrations and exposure periods for the salt treatment have rarely been reported.

Carp farming is a common aquaculture practice in Turkey. Carp, mainly mirror carp, is raised in freshwater ponds. Although the total production amount can vary yearly, cultured carp reached 293 tonnes in 2022 (Anonymous, 2023a). Further, carp is used for stocking activities in natural freshwater bodies. The number of carp stocked in 833 freshwater sources was approximately 7 million in 2020 (Anonymous, 2023b). Like any aquaculture industry, Turkish carp farming faces challenges such as disease management, water quality and market competition.

The main aim of the present study was to establish the anti-parasitic efficacy of salt in carp (*Cyprinus carpio*) infected with *Dactylogyrus extensus*.

## Materials and Methods

### *Source of Fish and Parasites*

Carp, *Cyprinus carpio* at the mean weight of 60 ±1.45 g were obtained from the Ankara University Aquaculture Unit, reared in the individual aquaponics system combining carp and mint (*Mentha* spp.) The stocking density of carp was 35 kg/m$^3$ in the 200-L fish tanks. Water quality parameters in the tanks were measured daily with the multi-probe device (YSI ProPlus) for the following parameters: temperature 20-22°C; dissolved oxygen 5.5-6.5 mg/L; pH 5.5-6.0. and the nitrite 0.18-0.80 mg/L. Fish were fed twice a day with a commercial feed, Sera Pond Bio Granulate (Crude Protein 28.9%, Fibre: 3.4%, Fat: 2.5%, Ash: 8.3%, Humidity: 6.1%) at a rate of 2% body weight. Fish were routinely examined under light anaesthesia with clove oil (50 mg/mL) for their health status and parasites. Examining the mucus from the gill filaments under a light microscope revealed the presence of a Monogenean gill parasite (Figure 1). A Monogenean parasite species was identified through their morphology and examination of their sclerotised structures under microscopy, following the criteria outlined by Pool & Chubb 1987, Soylu & Emre 2007, and Dzika et al. 2009. Accordingly, the parasite species on the gill filaments of *C. carpio* was identified as *Dactylogyrus extensus.*

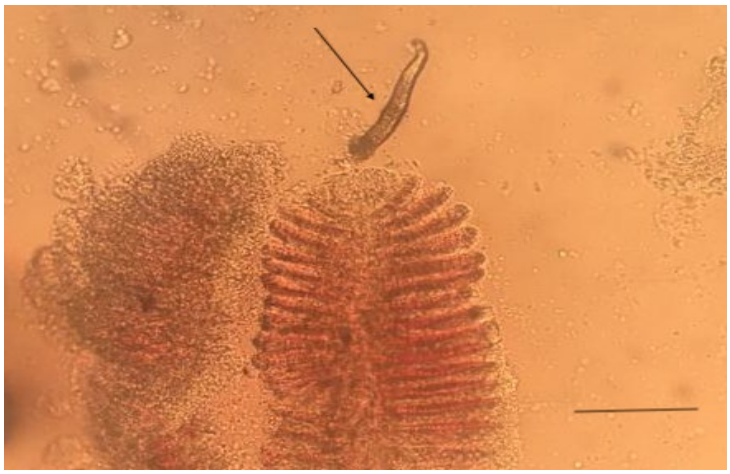


**Figure 1.** *Dactylogrus extensus* (bar:100 μm)

For the experiments *in vitro* and *in vivo*, the parasite samples were picked up by delicately scraping the gills surface's mucosa and placed onto glass microscope slides containing 200 μL well. The parasites were counted under the light microscope. The scrapped mucosa samples from the surface of the gills were weighed using an analytical balance (CHYO JL-200) having high sensitivity. *In vivo* tests, the gill mucosa scrappy procedure was done under light anaesthesia with eugenol (5 mg/L).

All handling and experimental procedures strictly adhered to the protocol approved by Ankara University Institutional Animal Ethical Committee. No fish were killed during the experiments.

### *Salt*

Salt was tested for its antiparasitic capacity *in vitro* and *in vivo* conditions. An inorganic salt source (Sodium chloride, Merck) was used to form different salinity levels the salt concentrations of 0.83, 1.25, 1.60 and 2.50 g/L were prepared for *in vitro* tests. The amount of salt was added to the tank water, which was previously filtered with a 0.22 μm filter and stirred to dissolve.

### *In Vitro Salt Test Against D. extensus*

*In vitro,* the effects of salt solutions on parasite survival were detected. Four different concentrations of salt (0.83, 1.25, 1.60 and 2.50 g/L) were tested. The exposure of parasites was applied by adding the salt solution to the glass slides with a well. Alive parasites were first transferred to the well and filled with tank water. Then, 100 μl of water from the well was removed using a micropipette, and 100 μl salt solution in the required concentration was added to the well to adjust the final concentration to be tested. Tank water was used for the survival of the control group, and the same procedure was applied to the parasites in the control group. The motility and contraction of parasites were continuously checked under a microscope to determine the time of death. Parasites were considered dead when there was no reaction to a touch by a thin needle. Mortality was recorded every five minutes. Three replicates (N=12 parasite each) were used per concentration of salt.

### *In Vivo Antiparasitic Efficacy Tests*

A total of 10 carp infected with *D. extensus* on the gill filaments were picked out from the aquaponics system for immersion experiments. *In vivo* salt solution was applied at the concentration of 1.25 g/L for 5 min. In the trials, fish were immersed in the salt in a 60-L aquarium containing 40-L of solutions for 5 min. After immersion, 10 fish were sampled for counting *D. extensus* on the gills. For the counting procedure, the scrapped mucus samples (0.0010 g) from the gills surface of the carp were used. Parasites in the mucus samples were counted before and after salt immersion of fish. The counts of live parasites in the mucus from the gills were assessed under a light microscope. The percent reduction in parasite numbers expressed the antiparasitic efficacy of the salt by Wang et al. (2008).

### *Statistical Analysis*

Data obtained from *in vitro* tests of concentrations were used for cumulative mortality. Other data were subjected to a variance analysis ANOVA, and the significance value of 5% was considered. SigmaExcel was used for all statistical analysis.

## Results and Discussion

While salt treatments can effectively combat certain parasites, it is essential to consider the correct dosage and species sensitivity to minimise the stress on the fish. Freshwater fish are more sensitive to changes in salt concentration. They are less tolerant of higher salt levels, making it necessary to find the correct salt concentration to kill the gills or skin parasites.

*In vitro,* the salt treatment decreased the survival of *D. extensus* in a dose and time-dependent pattern in the present study. *In vitro,* the cumulative parasite mortality reached 100% efficacy at the concentration of 2.50 g/L in 5 min while at 0.83 g/L in 25 min. A similar manner of anti-parasitic efficacy in terms of time and concentration-dependent pattern was also reported by Schelkle et al. (2011) and Tancredo et al. (2019), showing a positive correlation between parasite mortality and the concentration as well as time elapsed. In line with the correlation finding between parasite mortality and salt concen-

tration, *in vitro,* the survival of *G. bullatarudis* and *G. turnbulli* (Monogenean) decreased significantly with increasing salinities (Schelkle et al., 2011). Similarly, the killing capacity of formalin for *D. minutus* was noted to increase with formalin concentration and time (Tancredo et al., 2019).

*In vitro,* mortality of *D. extensus* changed by both the concentrations and exposure time of salt solutions, $p<0.05$ ($F_{crit}$=2,4858). A 100% cumulative mortality was reached in 5 min for the salt concentration of 2.50 g/L, while for the salt concentration of 0.83 g/L, the cumulative mortality of 100% was observed in 25 min (Figure 2).

***In Vivo Antiparasitic Efficacy***

*In vivo, the* intensity of *D. extensus* on the gills of carp was significantly decreased by salt treatment with a concentration of 1.25 g/L for 10 min ($p<0.05$). The mean intensity of *D. extensus* in the mucus of the gill surface (0.001 g) was 40.2±3.55 before treatment and decreased to 30.73±6.35 after treatment with salt (Figure 3). The salt treatment reduced *D. extensus* on the gills at a ratio of 23.56%.

The treatment strategy to eliminate Monogeneans infections requires *in vitro* tests as a preliminary phase (Tavares-Dias, 2018; Gonzales et al., 2020). In our study, *in vivo* application of salt, the concentration of 1.25 g/L min at 10 min was effective at 23.56%. The reduction *in vitro* in the survival of *D. extensus* after exposure to the salt was not the same as the reduction *in vivo* tests in carp. Direct contact of parasites with the salt accelerated the death of *D. extensus in vitro*. The comparatively reduced effectiveness of salt treatment can be attributed to the shielding impact of mucus and the parasites' positioning on the gill tissue, as observed in *in vivo* experiments. Similarly, the estimated correlation between salinity degree and survival of Gyrodactylids (Monogenea) was not reflected in the *in vivo* experiments with guppies, resulting from the envelopment of the parasite with the fish mucus (Schelkle et al., 2011). Confirmingly, salt bath was ineffective against Monogenean, *Gyrodactylus salaris* infecting *S. trutta m. trutta* and *S. trutta m. lacustris* as observed in long-term farm studies (Rintamäki-Kinnunen & Valtonen 1996). The difference in findings between *in vitro* and *in vivo* results was also observed for the Crustacean parasite, *Argulus*, associated with protecting *Argulus* by the scales of *Carassius auratus* treated with azadirachtin (Kumar et al., 2012). Ultimately, the action mechanism of salt to kill the Monogenean parasite can be explained by the disruption of the osmoregulatory function of the parasite (Hutson et al., 2018); however, this mechanism may fail to some extent due to the mucus layer and their ability to penetrate the gill filaments in the *in vivo* conditions (Trujillo-González et al. 2015). Thus, salt treatment can be ineffective in practice of fish culture, should be considered in treatment of monogeneans in freshwater fish.

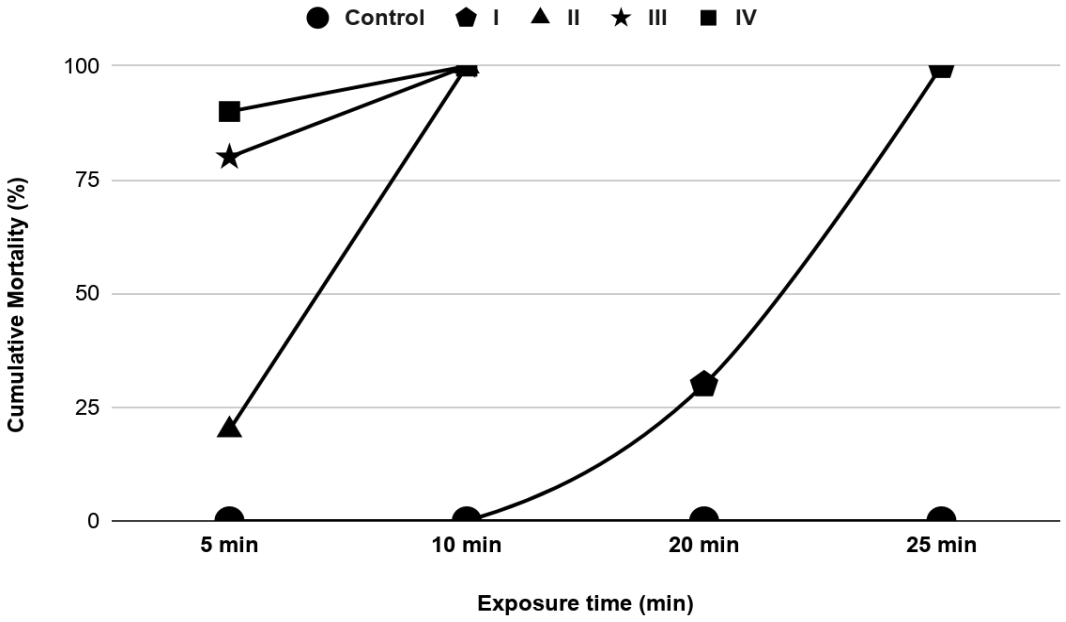



**Figure 2.** Cumulative mortality of *D. extensus* (Monogenean) exposed to salt. Concentrations (g/L): I-0.83; II-1.25; III-1.60; IV-2.50. Control: No salt exposure

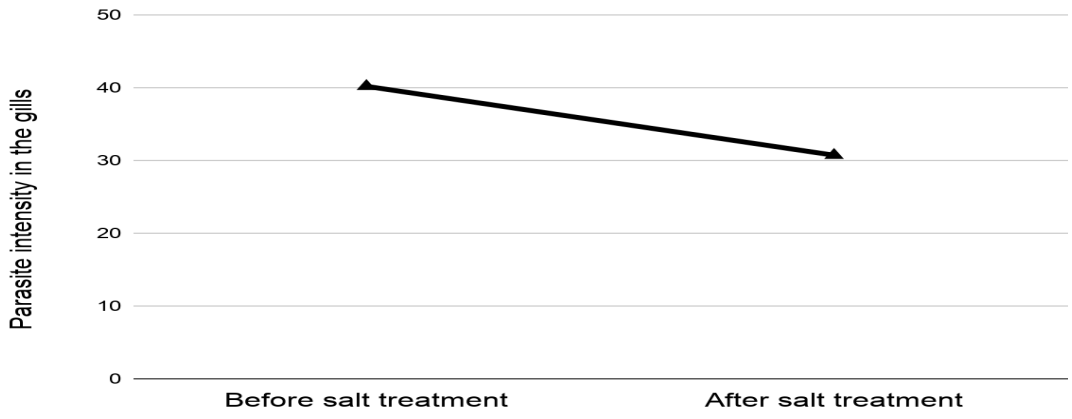



**Figure 3.** Reduction in *D. extensus* intensity in the gills of carp after treatment with salt

On the other hand, salt treatment may impact the sensitive gill tissue of freshwater fish species. However, this study did not encompass the histopathological alteration of gill tissue after salt exposure.

## Conclusion

*D. extensus* is highly sensitive against salt in *in vitro* conditions. *In vitro*, the mortality of *D. extensus* displayed clear dependence on both time and dosage, with higher salt concentrations leading to a reduced parasite survival time. The effectiveness of the anti-parasitic action of salt, achieved by immersion carp in a concentration of 1.25 g/L for 10 min, can be categorised as ranging from mild to moderate level. Treatment protocols for salt against monogeneans are complex because the exposure time and concentration are parasites and fish species-specific.

**Compliance with Ethical Standards**

**Conflict of interest:** The author declares that they have no actual, potential, or perceived conflict of interest for this article.

**Ethics committee approval:** All handling and experimental procedures strictly adhered to the protocol Ankara University Institutional Animal Ethical Committee approved.

**Data availability:** Data will be made available on request.

**Funding disclosure:** -

**Acknowledgements:** The author thanks MSc. Bilgenur Harmansa Yılmaz for her help in laboratory analysis.

**Disclosure:** -

## References

**Anonymous (2023a).** Turkish Statistical Institute. https://data.tuik.gov.tr/Search/Search?text=su%20%C3%BCr%C3%BCnleri&dil=1 (accessed 26.09.2023)

**Anonymous (2023b).** Su Ürünleri İstatistikleri. Balıkçılık ve Su Ürünleri Genel Müdürlüğü. https://www.tarimorman.gov.tr/sgb/Belgeler/SagMenuVeriler/BSGM.pdf (accessed 26.09.2023)

**Buchmann, K., Bresciani, J., Jappe, C. (2004).** Effects of formalin treatment on epithelial structure and mucous cell densities in rainbow trout, *Oncorhynchus mykiss* (Walbaum), skin. *Journal of Fish Diseases,* 27:99–104. https://doi.org/10.1111/j.1365-2761.2003.00519.x

**Burka, J.F., Hammell, K.L., Horsberg, T.E., Johnson, G. R., Rainnie, D. J., Speare, D. J. (1997).** Drugs in salmonid aquaculture - A review. *Journal of Veterinary Pharmacology and Therapeutics*, 20:333–349. https://doi.org/10.1046/j.1365-2885.1997.00094.x

**De Boeck, G., Vlaeminck, A., Van Der Linden, A., Blust, R. (2000).** The energy metabolism of common carp (*Cyprinus carpio*) when exposed to salt stress: An increase in energy expenditure or effects of starvation? *Physiological and Biochemical Zoology*, 73, 102–111. https://doi.org/10.1086/316717

**Diggles, B.K., Arlinghaus, R., Browman, H.I., Cooke, S.J., Cowx, I.G., Kasumyan, A.O., Key, B., Rose, J.D., Sawynok, W., Schwab, A., Skiftesvik, A.B. (2017).** Response to: Responses of larval zebrafish to low pH immersion assay. Comment on Lopez-Luna et al. Comment. *Journal of Experimental Biology*, 220, 3192–3194. https://doi.org/10.1242/jeb.162834

**Dzika, E., Dzikowiec, M., Hoffmann, R.W. (2009).** Description of the development of the attachment and copulatory apparatus of *Dactylogyrus extensus* from *Cyprinus carpio* var. koi. *Helminthologia*, 46, 39-44. https://doi.org/10.2478/s11687-009-0008-9

**Fajer-Ávila, E.J., Velásquez-Medina, S.P., Betancourt-Lozano, M. (2007).** Effectiveness of treatments against eggs, and adults of *Haliotrema* sp. and *Euryhaliotrema* sp. (Monogenea: Ancyrocephalinae) infecting red snapper, Lutjanus guttatus. *Aquaculture*, 264, 66-72. https://doi.org/10.1016/j.aquaculture.2006.12.035

**García-Magaña, L., Rodríguez-Santiago, M.A., Grano-Maldonado, M.I., Jiménez-Vasconcelos, L., Guerra-Santos, J. (2019).** The effectiveness of sodium chloride and formalin in trichodiniasis of farmed freshwater tilapia *Oreochromis niloticus* (Linnaeus, 1758) in southeastern Mexico. *Latin American Journal of Aquatic Research*, 47, 164–174. https://doi.org/10.3856/vol47-issue1-fulltext-18

**Gonzales A.P., Yoshioka E.T., Mathews P.D., Mertins, O., Chaves, F.C., Videira, M.N., Tavares-Dias, M. (2020).** Anthelminthic efficacy of Cymbopogon citratus essential oil (Poaceae) against monogenean parasites of *Colossoma macropomum* (Serrasalmidae), and blood and histopathological effects. *Aquaculture*, 528, 735500. https://doi.org/10.1016/j.aquaculture.2020.735500

**Hu, Y., Liu, L., Liu, G.L., Tu, X., Wang, G.X., Ling, F. (2017).** Synthesis and anthelmintic activity of arctigenin derivatives against *Dactylogyrus intermedius* in goldfish. *Bioorganic & Medicinal Chemistry Letters*, 27, 3310-3316. https://doi.org/10.1016/j.bmcl.2017.06.023

**Hutson, K.S., Brazenor, A.K., Vaughan, D.B., Trujillo-González, A. (2018).** Monogenean Parasite Cultures: Current Techniques and Recent Advances. *Advances in Parasitology*, 99, 61-91. https://doi.org/10.1016/bs.apar.2018.01.002

**Jerônimo, G.T., Marchiori N.C., de Pádua, S.B., Neto, J.D., Pilarski, F., Ishikawa, M.M., Martins, M.L. (2012).** *Trichodina colisae* (Ciliophora: Trichodinidae): New parasite records for two freshwater fish species farmed in. *Revista Brasileria de Parasitologia Veterinaria*, 21, 366-371. https://doi.org/10.1590/S1984-29612012005000008

**Kayis, S., Ozcelep, T., Capkin, E., Altinok, I. (2009).** Protozoan and metazoan parasites of cultured fish in Turkey and their applied treatments. *Israeli Journal of Aquaculture* - Bamidgeh, 61, 93-102. https://doi.org/10.46989/001c.20550

**Kotob, M.H., Menanteau-Ledouble, S., Kumar, G., Abdelzaher, M., El-Matbouli, M. (2016).** The impact of co-infections on fish: a review. *Veterinary Research*, 47, 1-12. https://doi.org/10.1186/s13567-016-0383-4

**Kumar, S., Raman, R.P., Kumar, K., Pandey, P.K., Kumar, N., Mohanty, S., Kumar, A. (2012)** In vitro and in vivo antiparasitic activity of Azadirachtin against *Argulus* spp. in *Carassius auratus* (Linn. 1758). *Parasitology Research*, 110, 1795-1800. https://doi.org/10.1007/s00436-011-2701-0

**Lieke, T., Meinelt, T., Hoseinifar, S.H., Pan, B., Straus, D.L., Steinberg, C.E. (2020).** Sustainable aquaculture requires environmental-friendly treatment strategies for fish diseases. *Rev Aquaculture*, 12, 943-965. https://doi.org/10.1111/raq.12365

**Pimentel-Acosta, C.A., Morales-Serna, F.N., Chávez-Sánchez, M.C., Lara, H.H., Pestryakov, A., Bogdanchikova, N., Fajer-Ávila, E.J. (2019).** Efficacy of silver nanoparticles against the adults and eggs of monogenean parasites of fish. *Parasitology Research*, 118, 1741-1749. https://doi.org/10.1007/s00436-019-06315-9

**Pool, D.W., Chubb, J.C. (1987).** Dactylogyrus extensus Mueller and van Cleave, 1932 and Dactylogyrus vastator Nybelin, 1924 on gills of common carp *Cyprinus carpio*. *Bulletin of the European Association of Fish Pathologists*, 7,

15-17.

**Reed, P., Francis-floyd, R., Klinger, R., Petty, D. (2012).** Monogenean Parasites of Fish. 1–10 https://fisheries.tamu.edu/files/2013/09/Monogenean-Parasites-of-Fish.pdf (accessed 28 08 2023). https://doi.org/10.32473/edis-fa033-2012

**Rintamäki-Kinnunen, P., Valtonen, E.T. (1996).** Finnish salmon resistant to Gyrodactylus salaris: A long-term study at fish farms. *International Journal for Parasitology*, 26, 723-732. https://doi.org/10.1016/0020-7519(96)00046-X

**Schelkle, B., Doetjes, R., Cable, J. (2011).** The salt myth revealed: Treatment of gyrodactylid infections on ornamental guppies, *Poecilia reticulata*. *Aquaculture*, 311, 74-79. https://doi.org/10.1016/j.aquaculture.2010.11.036

**Soylu, E., Emre, Y. (2007).** Monogenean and cestode parasites of *Pseudophoxinus* antalyae, Bogutskaya 1992 and *Cyprinus carpio*, Linnaeus 1758 from Kepez Antalya, Turkey. *Bulletin-European Association of Fish Pathologists*, 27, 23-28

**Tancredo, K.R., Marchiori, N.C., Pereira, S.A., Martins, M.L. (2019).** Toxicity of formalin for fingerlings of *Cyprinus carpio* var. koi and in vitro efficacy against *Dactylogyrus minutus* Kulwièc, 1927 (Monogenea: Dactylogyridae). *Journal of Parasitic Diseases*, 43, 46-53. https://doi.org/10.1007/s12639-018-1056-1

**Tavares-Dias, M. (2018).** Current knowledge on use of essential oils as alternative treatment against fish parasites. *Aquatic Living Resources*, 31, 13. https://doi.org/10.1051/alr/2018001

**Trujillo-González, A., Constantinoiu, C.C., Rowe, R., Hutson, K.S. (2015).** Tracking transparent monogenean parasites on fish from infection to maturity. *International Journal for Parasitology: Parasites and Wildlife*, 4, 316-322. https://doi.org/10.1016/j.ijppaw.2015.06.002

**Velasco-Santamaría, Y.M., Cruz-Casallas, P.E. (2008).** Behavioural and gill histopathological effects of acute exposure to sodium chloride in moneda (Metynnis orinocensis). *Journal of Veterinary Pharmacology and Therapeutics*, 25, 365-372. https://doi.org/10.1016/j.etap.2007.12.002

**Wang, G., Zhou, Z., Cheng, C., Yao, J., Yang, Z. (2008).** Osthol and isopimpinellin from Fructus cnidii for the control of *Dactylogyrus intermedius* in *Carassius auratus*. *Veterinary Parasitology*, 158, 144-151. https://doi.org/10.1016/j.vetpar.2008.07.034

**Whittington, I.D. (2005).** Monogenea Monopisthocotylea (ectoparasitic flukes). In: Rohde K (ed) Marine Parasitology. CSIRO, pp 63-72.

**Zhang, X.P., Li, W.X., Ai, T.S., Zou, H., Wu, S.G., Wang, G.T. (2014).** The efficacy of four common anthelmintic drugs and traditional Chinese medicinal plant extracts to control *Dactylogyrus vastator* (Monogenea). *Aquaculture*, (420-421), 302-307. https://doi.org/10.1016/j.aquaculture.2013.09.022

AQUATIC RESEARCH

E-ISSN 2618-6365

Aquatic Research 7(1), 8-14 (2024) • https://doi.org/10.3153/AR24002 *Research Article*

# Length-based growth, mortality, and biological reference points of *Chrysichthys nigrodigitatus* (Lacepède, 1803) from the Yeji arm of Lake Volta, Ghana

**Samuel K.K. AMPONSAH**

**Cite this article as:**
Amponsah, S.K.K. (2024). Length-based growth, mortality, and biological reference points of *Chrysichthys nigrodigitatus* (Lacepède, 1803) from the Yeji arm of Lake Volta, Ghana. *Aquatic Research*, 7(1), 8-14. https://doi.org/10.3153/AR24002

Department of Fisheries and Water Resources, University of Energy and Natural Resources, Box 214, Sunyani, Ghana

**ORCID IDs of the author(s):**
S.K.K.A. 0000-0001-5559-3139

**Submitted:** 19.09.2023
**Revision requested:** 27.09.2023
**Last revision received:** 03.10.2023
**Accepted:** 07.10.2023
**Published online:** 27.11.2023

**Correspondence:**
Samuel K.K. AMPONSAH
**E-mail:** samuel.amponsah@uenr.edu.gh



Available online at
http://aquatres.scientificwebjournals.com

## ABSTRACT

Individuals of *Chrysichthys nigrodigitatus* from Lake Volta, Ghana (West Africa), were examined between January and December 2020 for growth, mortality, and exploitation rate using total length measurement. Monthly length-frequency data were collected from 244 samples and analysed using the FiSAT II Tool. The estimated asymptotic total length (L∞), the coefficient of growth (K), and the calculated growth performance index (phi) were 27.3 cm, 0.57, and 2.63 per year, respectively. The total mortality rate (Z), natural mortality rate (M), and fishing mortality rate (F) were 1.57, 0.92, and 0.66 per year, respectively. The exploitation rate (E = 0.42) was below the optimum level of 0.5, which indicates that the species is underexploited. Based on the Emsy (0.56) value, analyses show that the exploitation rate is below the sustainable limit, hence the need for continuous monitoring of fishing efforts to ensure that the limit reference point is not exceeded.

**Keywords:** Ghana, Inland fishes, Fisheries management, Population parameters, FiSAT II

## Introduction

The silver catfish (*Chrysichthys nigrodigitatus*), which belongs to the Claroteidae family, occurs in most of Africa's major rivers, including Ghana (Ezenwa, 1981). The Family Claroteidae was carved from the traditional Bagridae to reflect a monophyletic group of African catfishes (Berra, 2001). They are highly valued food fish in most native African waters and are among the prevailing inland fish of commercial catches (Ikongbeh *et al.,* 2015). Because of the bottom-dwelling habit, this fish species is primarily harvested with a dragnet, hook and line, bottom-set gillnet, and bottom-set traps (Offem *et al.,* 2008).

Chrysichthys (Pisces: Siluriformes: Claroteidae) species consistently supports inland artisanal fisheries, both economically and in nutrition for communities along Lake Volta, Ghana (Ikongbeh *et al.,* 2015). The most commonly found species of Chrysichthys in Ghana include *C. walkeri, C. auratus, C. maurus, C. johnelsi,* and *C. nigrodigitatus* (Dankwa *et al.,* 1999), with *C. nigrodigitatus* as the most dominant species (Nelson, 2006). Fishermen residing in fishing villages along the lake Volta engage different types of fishing gear in the exploitation of *C. nigrodigitatus.* These gears include gillnets of various mesh sizes, cast nets, bamboo, traps, and hooks (Ajagbe *et al.,* 2021). Despite being present in most inland waters of Ghana, the stock of *C. nigrodigitatus* is profusely exhibiting a decline due to environmental degradation and overfishing (Adite *et al.,* 2017). This is evinced by the prominent appearance of smaller-sized individuals and juveniles of *C. nigrodigitatus* in the catches of fishermen, an indication of growth overfishing (Ofori-Danson *et al.,* 2002).

In Ghana, the only study (i.e., Ofori-Danson *et al.,* 2002) done on the population parameters of the species Lake Volta, Ghana, was carried out approximately two decades ago, which has dire implications for managing this valuable fish stock. Therefore, to update information on population parameters for this species, the study's main objective was to assess the growth, mortality, and exploitation rate of *C. nigrodigitatus* of Lake Volta, Ghana. Such scientific information will foster the implementation of proper management measures to sustain the assessed fish species in Lake Volta, Ghana.

## Materials and Methods

### *Study Area*

Four landing communities within Stratum VII of Lake Volta were selected, between longitude 0°10’ and 1°05W and latitude 8°8’ and 8°20’N and extending 60 km south and 50 km north of Yeji. These communities were Tonka, Vutideke, Brekente and Fante Akura, all landing sites within the Stratum VII of Lake Volta (Figure 1). Yeji is the capital of Pru District in the Brong-Ahafo region, with a population of 28.515 (GSS, 2014). Selection of these sampling inland fishing communities was based on two-stage stratified sampling criteria: geographical isolation and the level of fishing activities based on the number of fishing boats.

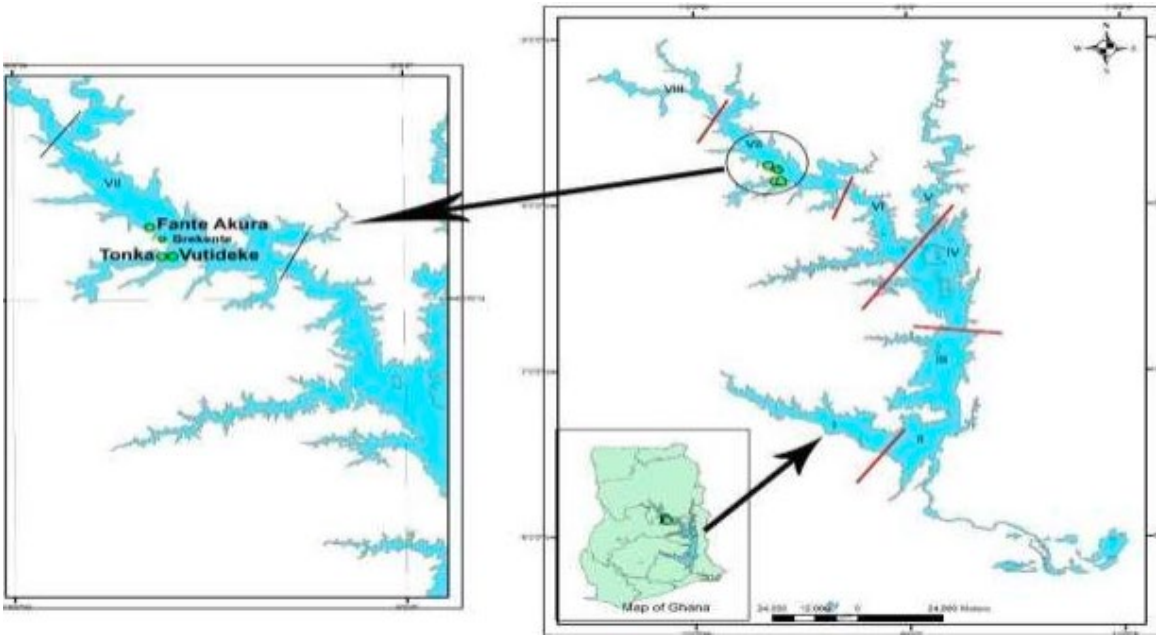



**Figure 1.** Map showing the fish landing sampling locations

### *Data Collection*

Individuals of the assessed fish species were obtained from randomly selected fishermen who applied different fishing gear in their fishing activities. These fishing gears involved bamboo, traps, and set gillnets (mesh size = 0.25 and 0.5 inches diagonally stretched). Samples were obtained over twelve (12) months (i.e., January to December 2020), preserved on ice, and analysed in situ. The species were identified to the lowest taxonomic level using identification keys by Dankwa *et al.* (1999). Measurement of length was performed using a 100 cm graduated wooden measuring board. In all, 244 specimens of *C. nigrodigitatus* were obtained during the study period.

### *Growth Parameters*

Parameters for which the fish growth is assumed to follow Von Bertalanffy Growth Function (VBGF), including growth rate (K) and asymptotic length ($L\infty$) were estimated.

Estimation of longevity ($T_{max}$) for the species was estimated:

$T_{max} = 3/K$ (Anato 1999).

The growth performance index was calculated using the formula:

$(\Phi') = 2\log L_\infty + \log K$ (Munro & Pauly, 1984).

The theoretical age at length zero (to) followed the equation:

$\text{Log}_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$ (Aleev, 1952).

### *Mortality Parameters*

Total mortality (Z) was computed using a Linearized length converted catch curve (Sparre & Venema, 1992).

The natural mortality rate (M) was calculated using the procedure:

$M = 4.118K^{0.73}L\infty^{-0.333}$ (Then *et al.*, 2015).

Fishing mortality (F) was calculated as:

$F = Z - M$ (Qamar *et al.*, 2016).

The exploitation rate (E) was computed using:

$E = F/Z$ (Georgiev and Kolarov, 1962).

### *Length at First Capture ($Lc_{50}$)*

The ascending left part of the length converted catch curve was used in estimating the probability of length at first capture ($Lc_{50}$) in addition to the length at both 25 and 75 percent capture, which correlates with the cumulative probability at 25% and 75% respectively (Pauly, 1984).

### *Biological Reference Points*

$E_{msy}$, which depicts the exploitation rate producing maximum yield, and $E_{0.5}$, implying the exploitation rate under which the population is reduced to half its virgin biomass, were computed using the knife edge selection options.

### *Data Analyses*

The length frequency data were pooled into groups with 2 cm length intervals. Then, the data was analysed using the FiSAT II Tool (Gayanilo *et al.,* 2002).

## Results and Discussion

### *Length Distribution Frequency*

The mean length of *C. nigrodigitatus* was 13.8, with minimum and maximum lengths of 7 cm and 25.1 cm recorded in January 2020 and March 2020, respectively. The modal length of the assessed fish species was 10 cm to 12 cm (Table 1).

### *Growth Parameters*

Figure 2 shows the restructured length frequency with superimposed growth curves. The asymptotic length ($L\infty$) was 27.3 cm. *C. nigrodigitatus* grew at a growth rate (K) of 0.57 per year with longevity ($T_{max}$) of 5.26 yr. The growth performance index ($\Phi'$) and age at length zero were estimated at 2.628 and -0.29, respectively. The VBGF for length at the time (t) was expressed as $L_t = 27.3 * (1\text{-}e^{-0.57\ (t + 0.29)})$.

### *Mortality Parameters*

From the length converted catch curve (Fig 3), the total mortality rate (Z) estimated was 1.57 per year. The natural mortality rate (M) was 0.92 per year, and the fishing mortality rate (F) was 0.66 per year. The exploitation rate (E) recorded for *C. nigrodigitatus* was 0.42.

### Length at First Capture ($Lc_{50}$)

The probability of capture was estimated as $L_{25}$ = 8.58 cm, $L_{50}$ = 9.66 cm and $L_{75}$ = 10.7 cm. Therefore, the length at first capture ($Lc_{50}$) was 9.66 cm.

### *Biological Reference Points*

From Fig 5, the indices for sustainable yield were 0.32 for optimum sustainable yield ($E_{0.5}$) and 0.56 for the maximum sustainable yield ($E_{msy}$).

**Table 1.** Length frequency distribution of *C. nigrodigitatus* from Stratum VII of Lake Volta, Ghana

| Upper limit | 2020 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Total** |
| 8 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 10 | 10 | 2 | 11 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 4 | 1 | 34 |
| 12 | 11 | 9 | 3 | 1 | 1 | 6 | 9 | 3 | 3 | 5 | 6 | 2 | 59 |
| 14 | 0 | 5 | 2 | 4 | 6 | 7 | 4 | 3 | 5 | 4 | 2 | 2 | 44 |
| 16 | 0 | 2 | 0 | 9 | 10 | 6 | 9 | 3 | 3 | 0 | 1 | 4 | 47 |
| 18 | 1 | 2 | 1 | 4 | 5 | 9 | 2 | 2 | 0 | 0 | 1 | 5 | 32 |
| 20 | 0 | 0 | 3 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 7 |
| 22 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 24 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 6 |
| 26 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Total** | **24** | **20** | **23** | **23** | **26** | **30** | **24** | **17** | **12** | **12** | **14** | **14** | **244** |

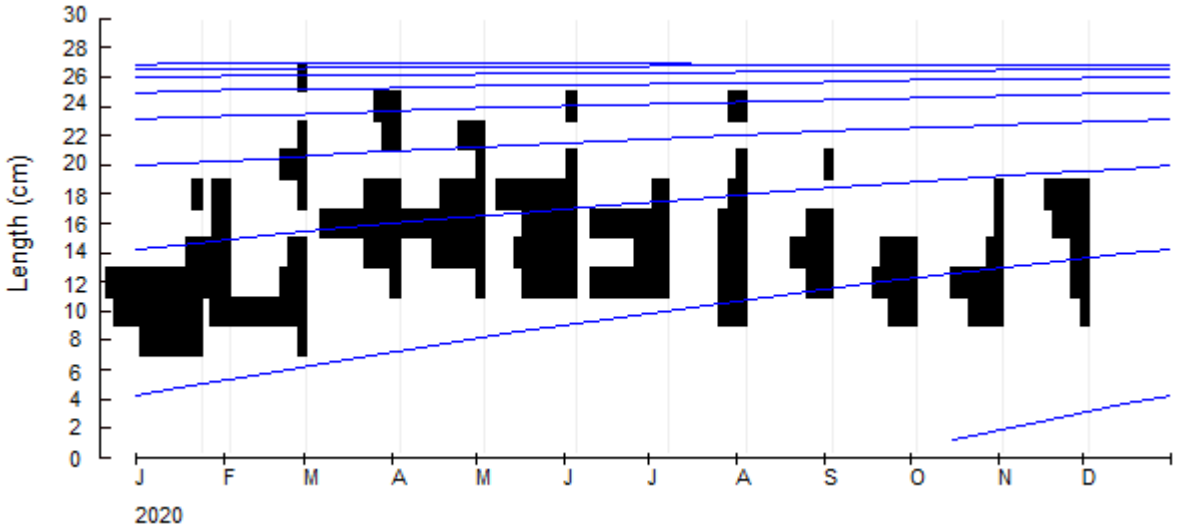



**Figure 2.** Reconstructed length frequency distribution superimposed with the growth curve

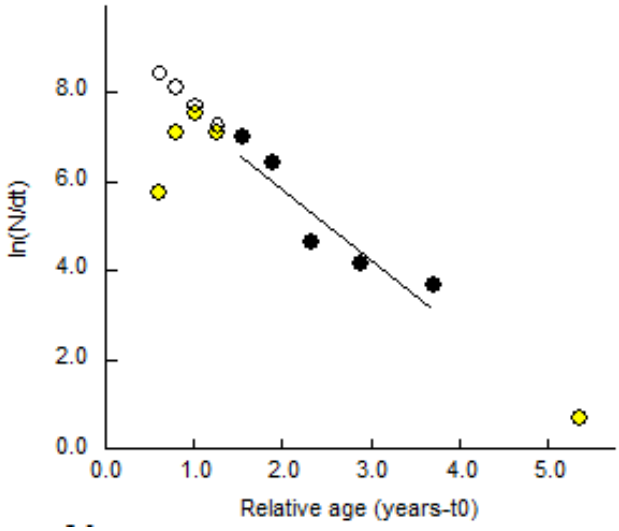



**Figure 3.** Linearized length-converted catch curve for estimation of instantaneous total mortality (Z)

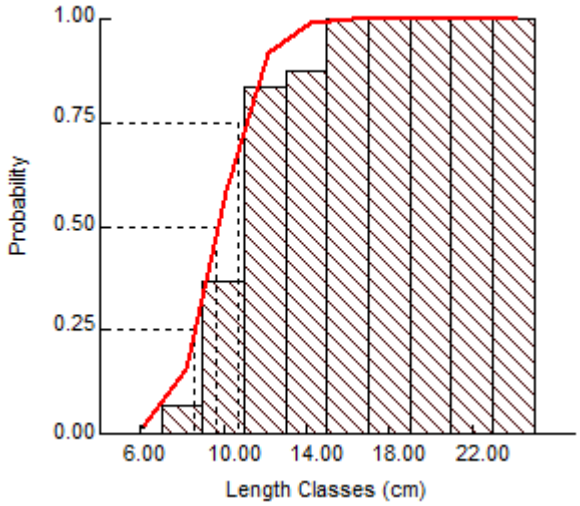



**Figure 4.** Probability of capture of *C. nigrodigitatus*

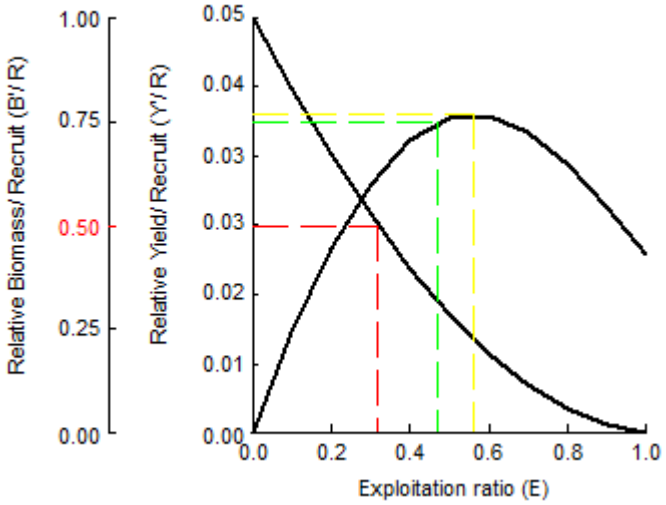



**Figure 5.** Yield per recruit analysis of *C. nigrodigitatus*

The study's maximum theoretical length (L∞) was 27.3 cm TL, which was lower than the estimated length recorded by Ofori-Danson *et al.* (2002). This suggests that small-sized individuals of this species from Lake Volta are facing high fishing pressure. Okogwu *et al.* (2010) assigned the observed difference in maximum theoretical length to the variability of the study environments and fishing pressure. The growth performance index from the present study (phi = 2.62) was outside the range (i.e. phi = 2.65 – 3.12) estimated by Baijot and Moreau (1997) for crucial African fish species showing slow growth. This fast growth exhibited by individuals of the species may be a coping strategy for high fishing pressure on Lake Volta, Ghana.

The size at first capture is a biological indicator and a vital parameter that indicates the health status of the resource (Kone *et al.,* 2022). The length at first capture from the study (i.e. 9.66 cm) was lower than the findings by Kone *et al.* (2022), Ajabge *et al.* (2021), and Udoidiong *et al.* (2016). In addition, the critical length at capture (Lc = 0.35) indicated that species are harvested at 35% of growth, higher than documented by Udoidiong *et al.* (2016), which, from a management perspective, is unhealthy for the sustenance of the stock. Furthermore, Lc < 0.5 signifies harvesting smaller individuals of the assessed fish species than adults. These findings from the study confirm the exploitation of more minor or juvenile individuals from Lake Volta. Such exploitation indicates growth overfishing, characterised by individuals having a lower chance of contributing significantly to the stock (Ofori-Danson *et al.,* 2002). The high abundance of juvenile individuals could be attributed to the excessive use of bamboo as fishing gear on the Lake. *Chrysichthys* sp. primarily views bamboo as spawning or breeding substrates; hence, there is a high possibility that fisherfolks who employ these fishing gears will harvest gravid individuals. Continuous indulgence in unsustainable fishing practices could impair the recruitment potential of the assessed fish species. This observation calls for mesh size regulation and a ban on the bamboo used for fishing this species, which will permit the escape of small-sized individuals.

According to Macer (1977), the consistency of the estimated natural mortality rates (*M*) was ascertained using the *M*/*K* ratio, which has been reported to be within the range of 1.12 and 2.5 for most fishes. The *M*/*K* ratio in this study (1.61) fell within the acceptable demarcated range, which shows the reliability of the estimates obtained for the present study. According to Cissé *et al.* (2021), the maximum level of exploitation of a resource is reached when fishing mortality (F) is equal to or higher than natural mortality (M). From the present study, the natural mortality rate (0.92 per year) was higher than the fishing mortality rate (0.66 per year), which is reflected in the low exploitation rate (E = 0.42). The relatively lower fishing mortality rate than the natural mortality rate from the current study points to an imbalanced stock position (Azim *et al.,* 2017), which is always expected in a natural system. Also, the low exploitation rate experienced by individuals of the species suggests that these individuals are underexploited (Gulland, 1971). Ofori-Danson *et al.* (2002) recorded a higher exploitation rate (E = 0.67) on *C. nigrodigitatus* from Lake Volta. Compared to the current study, the variation in exploitation rate may be due to fishermen exploiting other commercially important fishes at a higher rate than the assessed fish species.

From the biological reference point of view, the exploitation rate for the assessed species in the present study was lower than that at maximum sustainable yield (Emsy = 0.56). This indicates that the assessed fish species is far from over-exploitation. Given this underexploited level of fishing, continuous monitoring of fishing efforts is essential. Furthermore, the possible creation of inland protected area (IPA) and implementation of closed fishing seasons could be applied to safeguard the species from exceeding the limit reference point.

## Conclusion

The study aimed to assess the growth, mortality, and biological reference points of *C. nigrodigitatus* from the stratum VII of Lake Volta, Ghana. From the study, *C. nigrodigitatus* recorded a growth rate of 0.57 per year, which signifies signs of fast growth. The exploitation rate (E = 0.42) was lower than the maximum sustainable yield exploitation rate (Emax = 0.56), which indicates that the species in Lake Volta, Ghana, is experiencing a low level form exploitation. In the wake of the low exploitation, there is a need to institutionalise specific management measures such as mesh size regulations, a ban on illegal fishing gears, closed fishing periods, and compliance to fisheries management measures.

**Compliance with Ethical Standards**

**Conflict of interest:** The author declares no actual, potential, or perceived conflict of interest for this article.

**Ethics committee approval:** -

**Data availability:** Data will be made available on request.

**Funding disclosure:** No funding provided.

**Acknowledgements:** Sincere gratitude goes to Mr. Mohammed, whose assistance during the fieldwork cannot be quantified. Also, appreciation goes to fishermen who willingly allowed us to take morphometric measurements of their catches.

**Disclosure:** -

## References

**Adite, A., Gbaguidi, H.M.G.A., Ategbo, J.M. (2017).** Reproductive biology and life history patterns of the Claroteid, *Chrysichthys nigrodigitatus* (Lacépède: 1803) from a Man-made Lake in Southern Benin. *Journal of Fisheries and Aquatic Science,* 12(3), 106-116. https://doi.org/10.3923/jfas.2017.106.116

**Ajagbe, S.O., Odulate, D.O., Ajagbe, R.O., Ariwoola, O.S., Abdulazeez, F.I., Oyewole, O.O., Oyekan, O.O. (2021).** Population dynamics of *Chrysichthys nigrodigitatus* (Lacépède, 1803) in Ikere-gorge, Oyo State, Nigeria. *Ghana Journal of Agricultural Science*, 56(1), 79-86. https://doi.org/10.4314/gjas.v56i1.6

**Aleev, Y.G. (1952).** *Horse Mackerel of the Black Sea*, 24 pp.

**Anato, C.B. (1999).** Les Sparidae des côtes béninoises: Milieu de vie, pêche, présentation des espèces et biologie de *Dentex angolensis* Poll et Maul, 1953. Thèse de Doctorat d'Etat es Sciences, Fac. Sci. 1060 Tunis, 277 p.

**Azim M.K.M., Amin S.M.N., Romano N., Arshad A., Yusoff F.M. (2017).** Population Dynamics of Yellowtail Scad, *Atule mate* (Cuvier 1833) in Marudu Bay, Sabah, Malaysia. *Sains Malaysiana*, 46(12), 2263- 2271. https://doi.org/10.17576/jsm-2017-4612-02

**Baijot, E., Moreau, J., Bouda, S. (1997).** Hydrobiological aspects of fisheries in small reservoirs in the Sahel region. Technical Centre for Agricultural and Rural Cooperation. Wageningen, The Netherlands, pp. 243.

**Berra, T.M. (2001).** Freshwater fish distribution. Academic press. San Diego, CA. ISBN: 978-0080532011

**Dankwa, H.R., Abban, E.K., Teugels, G.G. (1999).** Freshwater fishes of Ghana: identification, distribution, ecological, and economic importance. 53pp.

**Ezenwa, B.I.O., Ikusemiju, K. (1981).** Age and growth determinations in the catfish, *Chrysichthys nigrodigitatus* (Lacépède) by use of the dorsal spine. *Journal of Fish Biology*, 19(3), 345-351. https://doi.org/10.1111/j.1095-8649.1981.tb05837.x

**Gayanilo, F.C., Sparre, P., Pauly, P. (2002).** *The FAO-ICLARM stock assessment tools II (FiSAT II) User's guide*. FAO, Rome.

**Georgiev, Z.M., Kolarov, P. (1962).** "On the migration and distribution of horse mackerel (Trachurus ponticus Aleev) in the western part of Black Sea," *Arbeiten des Zentralen Forschungsinstitutes für Fishzucht und Fisherei Varna*, 2, 148-172.

**Ghana Statistical Service (GSS).** (2014). The Ghana living standards survey round six (GLSS6).

**Gulland, J.A. (1971).** The fish resources of the oceans. West by fleet survey. Fishing News (Books) Ltd., for FAO, West By fleet, England: 255. ISBN: 1341661490

**Kone, N., N'da A.S., Badia A.T., Boguhe B.F.H.D., Berte, S. (1995).** Growth, exploitation parameters and sexual maturity of *Chrysichthys nigrodigitatus* (Lacépède, 1803) downstream of the Taabo dam (Bandama River, Côte d'Ivoire). *International Journal of Fisheries and Aquatic Studies*, 10(4), 200-205.
https://doi.org/10.22271/fish.2022.v10.i4c.2713

**Macer, C.T. (1977).** Some aspects of the biology of the horse mackerel [*Trachurus trachurus* (L.)] in waters around Britain. *Journal of Fish Biology*, 10(1), 51-62.
https://doi.org/10.1111/j.1095-8649.1977.tb04041.x

**Munro, J.L. Pauly, D. (1984).** Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte, 2, 21.

**Nelson, J.S. (2006).** Fishes of the World. 4th Edition. John Wiley & Sons, Inc., 624 pp ISBN: 978-0471250319

**Obeten Offem, B., Akegbejo-Samsons, Y., Tunde Omoniyi, I. (2008).** Diet, size and reproductive biology of the silver catfish, *Chrysichthys nigrodigitatus* (Siluformes: Bagridae) in the Cross River, Nigeria. *Revista de Biología Tropical,* 56(4), 1785-1799.
https://doi.org/10.15517/rbt.v56i4.5759

**Ofori-Danson, P.K., De Graaf, G.J., Vanderpuye, C.J. (2002).** Population parameter estimates for *Chrysichthys auratus* and *C. nigrodigitatus* (Pisces: Claroteidae) in Lake Volta, Ghana. *Fisheries Research,* 54(2), 267-277.
https://doi.org/10.1016/S0165-7836(00)00292-7

**Okogwu, O.I., Ajuogu, J.C., and Nwani, C.D. (2010).** Artisanal fishery of the exploited population of *Macrobrachium vollenhovenii* Herklot 1857 (Crustacea; Palaemonidae) in the Asu River, southeast Nigeria. *Acta Zoologica Lituanica,* 20(2), 98-106.
https://doi.org/10.2478/v10043-010-0011-x

**Pauly, D. (1984).** Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Contribution, Makati, Metro, Manila, Philippines, (143): pp. 325.

**Qamar, N, Panhwar, S. K. and Brouwer, S. (2016).** Population Characteristics and Biological Reference Point Estimates for Two Carangid Fishes, *Megalaspis cordyla* and *Scomberoides tol,* in the Northern Arabian Sea Coast of Pakistan. *Pakistan Journal of Zoology*, 48(3), 869-874.

**Sparre, P., Venema, S.C. (1992).** Introduction to tropical fish stock assessment. FAO Fish. ISBN: 978-9251028506

**Then, A.Y., Hoenig, J.M, Hall, N.G., Hewitt D.A. (2015).** Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES *Journal of Marine Science*, 72, 82-92.
https://doi.org/10.1093/icesjms/fsu136

**Udoidiong, O.M., Ukpatu, J.E., Udoh, J.P. (2016).** Recruitment pattern and length-at-first capture of the silvercatfish Chrysichthys nigrodigitatus Lacépède (1803): claroteidae in Lower Cross River, Southeast Nigeria. *Tropical Freshwater Biology*, 25, 1-11.
https://doi.org/10.4314/tfb.v25i1.1

AQUATIC RESEARCH

AQUATIC RESEARCH
E-ISSN 2618-6365

Aquatic Research 7(1), 15-29 (2024) • https://doi.org/10.3153/AR24003 *Research Article*

# The impact of the COVID-19 pandemic on fish and food perception, consumption, and purchasing behaviors of Turkish consumers

**Sühendan MOL[1], Seda KARAKAŞ GEYİK[2], Yusuf SÜREN[3]**

**Cite this article as:**
Mol, S., Karakaş Geyik, S., Süren, Y. (2024). The impact of the COVID-19 pandemic on fish and food perception, consumption, and purchasing behaviors of Turkish consumers. *Aquatic Research*, 7(1), 15-29. https://doi.org/10.3153/AR24003

[1] Istanbul University, Faculty of Aquatic Sciences, Department of Fisheries and Seafood Processing Technology, Fatih, İstanbul, Türkiye

[2] Istanbul University, Faculty of Economics, Department of Econometrics, Beyazıt, Fatih, İstanbul, Türkiye

[3] İstanbul University, Institute of Science, Department of Fisheries and Seafood Processing Technology, Seafood Processing Technology Program (MSc Student), Fatih, İstanbul, Türkiye

**ORCID IDs of the author(s):**
S.M. 0000-0003-3831-5107
S.K.G. 0000-0003-2218-6689
Y.S. 0009-0005-6233-0886

**Submitted:** 19.09.2023
**Revision requested:** 05.10.2023
**Last revision received:** 09.10.2023
**Accepted:** 16.10.2023
**Published online:** 06.12.2023

**Correspondence:**
Sühenadan MOL
**E-mail:** suhendan@istanbul.edu.tr



Available online at
http://aquatres.scientificwebjournals.com

## ABSTRACT

The fact that the coronavirus was detected in the Wuhan fish market has affected attitudes toward food, especially fish. This survey questioned the opinions and behaviours during and after lock-downs to understand the temporary and permanent effects of the pandemic. Respondents were concerned about virus transmission from food, especially during lockdowns (58%), while less concerned about transmission from fish (22.9%). Although the majority (57.1%) think that eating fish protects against the virus, they (>60%) did not tend to consume more fish. Most respondents (49.6%) were concerned about food shortages and experienced food insecurity. Food consumption increased (58%) during lockdowns but decreased (29%) afterwards. Vegetables/fruits (51.4%), bakery (48.4%), grains/legumes (37.5%) consumption increased due to home cooking, and chicken preferred as animal protein. Although respondents preferred to buy online and packaged food, the majority (>60%) were concerned about the freshness of online-ordered fish and did not prefer it (>80%). Participants stocked food during the lockdowns (47.3%) but did not make it a habit afterwards. Respondents' answers showed that fish prices increased for budget during the pandemic. Findings will be helpful for the seafood sector and contribute to creating resilient and sustainable food environments that can better respond to future shocks that may affect humanity.

**Keywords:** Pandemic, Seafood, Food security, Attitudes, Fisheries

## Introduction

The first SARS-CoV-2 virus, coronavirus, was identified in China in December 2019. The coronavirus was initially detected in the seafood and animal market in Wuhan (Sağlık Bakanlığı, 2023). Then, the number of cases outside of China and the number of countries with cases increased rapidly, and the World Health Organization (WHO, 2023a) declared the novel coronavirus (COVID-19) pandemic on March 11, 2020. As of May 2020, the COVID-19 pandemic caused approximately 330,000 million people to be infected and 14,510 people to die worldwide (WHO, 2023b). In December 2020, the WHO announced that the governments should implement lockdown measures to isolate and quarantine all contacts (WHO, 2023c). Following this, countries started to implement these measures. On April 14, 2021, a partial lockdown was declared in Türkiye, restricting going out after 7 p.m. on weekdays and weekends (Ministry of Interior, 2021a). Then, a complete lockdown was declared from 29 April 2021 to 17 May 2021(Ministry of Interior, 2021b). After this date, the nighttime and weekend lockdowns were enforced, and as of July 1, 2021, the lockdowns were ended (Ministry of Interior, 2021c). Similar lockdowns and restrictions were imposed in most countries around the world.

The size of the pandemic, lockdowns, and quarantine have created psychosis and panic in the public. Worldwide health crises of this magnitude are rare and lead to many lasting global changes. Indeed, the Covid-19 pandemic has had a significant impact, causing economic, sociocultural, and behavioural changes (UN, 2020). The pandemic has affected individuals in terms of dietary habits, and people have realised that food security and availability are vital needs (Pulighe & Lupia, 2020). Movement restrictions, limited access to grocery stores, restaurant closures, disruption of the food supply chain, and stay-at-home announcements have affected consumers' food-related behaviours and led to changes such as stockpiling, panic buying, home cooking, and online shopping (Cranfield, 2020; Mandal et al., 2021). In a very recent study, Galanakis (2023) reported that the effects of the pandemic on food security continue today and emphasised that the pandemic will lead to food insecurity in the future due to limited food access, increased food costs, disrupted global trade, and deficiencies in food distribution. Therefore, more research is needed to create sustainable policies to ensure food security during such shocks that may occur in the future (Mandal et al., 2021).

As well as other foods, the fact that the coronavirus was first detected in the Wuhan fish market reveals the potential for people to be particularly concerned about fish consumption. Therefore, it is necessary to examine the impact of the pandemic on opinions and behaviours related to fish consumption. Akdemir et al. (2020) emphasised the importance of studies determining this pandemic's medium and long-term impact on fish and other food-related behaviours. The head of the UN World Health Organization (WHO) stated that even though the emergency regarding COVID-19 is over, the disease remains a global threat and reminded that the risk of new variants causing new cases and deaths continues (UN, 2023). Understanding communities' perceptions of food, access to food, and particularly micronutrient-dense food such as fish will enable governments to better respond to shocks that may affect humanity in the future (Love et al., 2021).

Considering these requirements, the current study aimed to determine the effects of the COVID-19 pandemic on (1) food safety and insecurity concerns, (2) fish and other food consumption preferences, and (3) fish and other food purchase patterns.

## Materials and Methods

### *Study Area*

The study was conducted in Istanbul, the most populated city in Türkiye. Istanbul, with a population of 15 907 951, constitutes 18.65% of Türkiye's population (Turkish Statistical Institute, 2022a) and is the province with the highest (98.7%) internet access rate (Turkish Statistical Institute, 2022b). Since Istanbul provides career and income opportunities, people from different social and cultural backgrounds live in this metropolitan.

### *Implementation of Surveys*

An electronic questionnaire was designed and applied to 10 people to test accuracy and comprehensibility. Ethical approval was obtained from the Istanbul University Ethics Committee (file number 2022/106). After the necessary arrangements, it was shared on Google's online survey platform and applied to 498 people between April and December 2022. The electronic survey form was sent to many people online via e-mail and social media applications. These people were invited to participate in the survey and were asked for the contact information of other people living in Istanbul. Thus, many people were reached through the snowball method, widely used for sample enrichment (Noy, 2008). Although internet access is high in Istanbul, 39 printed questionnaires were applied face-to-face to Istanbul University cleaning workers to collect data from people with low education and/or income levels who may not be reached via online forms. At the first step of the survey, people were informed

that they were free to decide to participate, to leave it at any time and that the survey results would be used for scientific publication. One (1) person disapproved, and only those who agreed could continue with the survey. Participants who agreed were asked whether they had any food science, dietetics, or nutrition education. The survey was terminated for 26 individuals replying to this question positively. In this way, it was ensured that the opinions of ordinary people who were not authorised in food-related fields were taken. Therefore, the questionnaire was completed by 510 people, excluding (1) who disapproved of participating in the survey and (26) who were educated in food, dietetics, or nutrition sciences. The sample size was determined according to Yamane (1967) formula. The population of Istanbul was used, the level of precision was chosen as 0.05, and the sample size was calculated as 399.98. The research sample of 537 is well above this number.

Participants were warned that only 1 person from each household should answer the form considering the COVID-19 pandemic conditions. Then, demographic questions were asked to determine the participant profile, and the socio-demographic characteristics were presented in Table 1. Income-related questions were asked in TL (Turkish Lira) and converted to US$ using the exchange rate (TCMB, 2023) at the time of the survey. The subsequent 13 questions focused on the impact of the COVID-19 pandemic on fish and other food consumption preferences, food safety and accessibility concerns, and food purchasing patterns. Since it was aimed to determine the temporary and permanent effects of the pandemic, these questions were asked about the opinions or behaviours during and after COVID-19 lockdowns. The questionnaire used a 3-point Likert scale as “Yes, No idea, No”. Apart from this, 2 other questions were asked about possible concerns about buying fish online: "If you order online, do you think the fish might spoil until it reaches you?" and "If you order online, do you think they send you stale fish?". These questions were asked as a general opinion independent of the lockdowns, and the answer options were “Yes, No idea, No”. It was also aimed to determine the impact of restaurant closures/restrictions and increased home cooking on food consumption during the pandemic. For this purpose, 6 leading food names, such as fish, bakery, red meat, poultry, vegetable-fruit, and grain-legume, were given. The last 2 questions were asked: "Are there any foods you consume less because you cannot go to restaurants / Are there any foods you consume more because you cook at home?" and multiple answers were allowed. Thus, 17 questions were asked of the participants apart from demographic questions.

**Table 1.** Socio-demographic characteristics of the study participants (n = 510)

| VARIABLES | Category | Number of respondents | Respondents in % |
|---|---|---|---|
| **Gender** | Male | 253 | 49.6 |
| | Female | 255 | 50.0 |
| | Not prefer to say | 2 | .4 |
| **Age** | <26 | 138 | 27.1 |
| | 26 - 40 | 210 | 41.2 |
| | >40 | 162 | 31.8 |
| **Education** | Primary education | 142 | 27.8 |
| | Secondary education | 156 | 30.6 |
| | Higher education | 212 | 41.6 |
| **Monthly income** | <341 $ | 102 | 20.0 |
| | 341 $ -682 $ | 219 | 42.9 |
| | 683 $ - 1365 $ | 146 | 28.6 |
| | >1365 $ | 43 | 8.4 |
| **Size of household** | 1 | 48 | 9.4 |
| | 2-4 | 343 | 67.3 |
| | 5-6 | 109 | 21.4 |
| | 7 + | 10 | 2.0 |
| **Working status** | Job loss | 63 | 12.4 |
| | No job loss | 447 | 87.6 |

### *Data Analysis*

The data analysis was conducted using SPSS 20 (Statistical Package for Social Sciences). Descriptive statistical analysis, including frequencies and percentages, was performed to summarise the socio-demographic characteristics of the respondents. Non-parametric analyses were employed due to the Likert-type measurement of the data.

The Non-Parametric Wilcoxon Signed Rank test for paired samples was employed to assess the presence of statistically significant differences in responses to fish and food-related questions during and after the lockdown periods. The questions can be found in Figure 1 and Figure 2. The analysis revealed a significant difference in all variables except for the question related to fish consumption ($p$-value < 0.05). Contrarily, for the question about fish consumption of 'eating more fish than before, during and after lockdowns, there was no statistically significant difference at the 0.05 confidence level ($p$-value > 0.05). Consequently, the findings indicate the absence of a statistically significant difference in fish consumption between the periods of lockdowns and post-lockdowns. After conducting the significance test, frequencies

and percentages were analysed to draw inferences about "*The impact of the Pandemic on food and fish consumption*," "*Tendency towards packaged food and online shopping due to virus concerns*," and "*Food insecurity*".

The demographic variables (gender, age, education, income) used in this study were measured with three or more categories. The Kruskal-Wallis test is a non-parametric test used to analyse the differences between means among three or more categorical groups of an independent variable. Therefore, the Kruskal-Wallis test was applied to examine the relationships between demographic variables and concerns about receiving spoiled or stale products when ordering fish online.

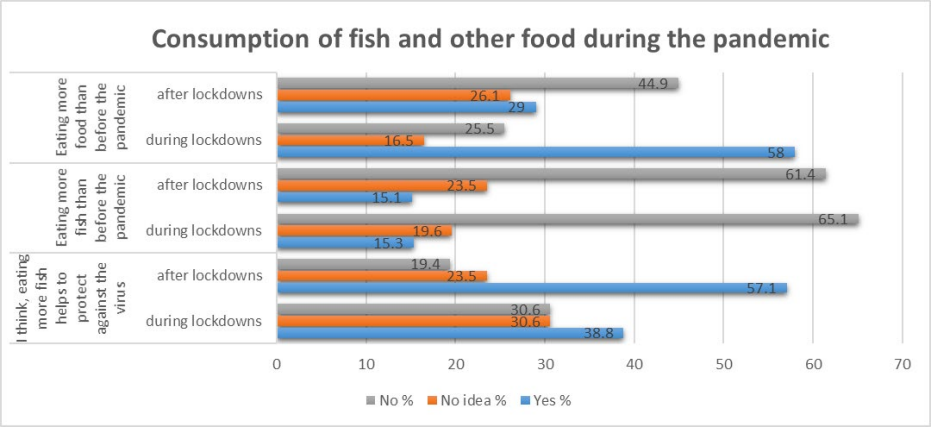
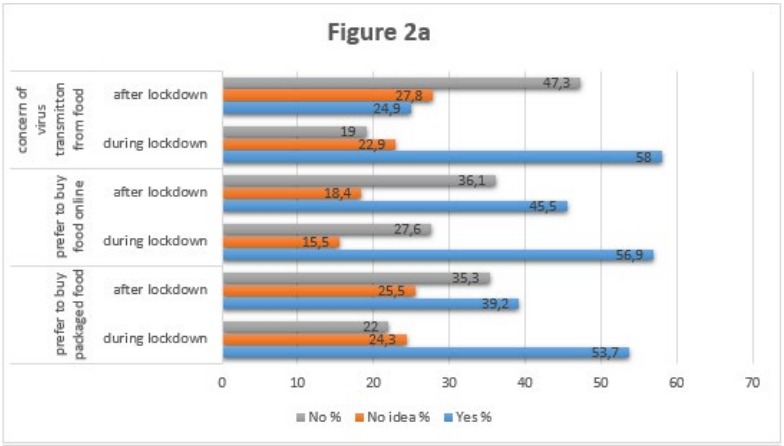



**Figure 1.** Consumption of fish and other food during the pandemic



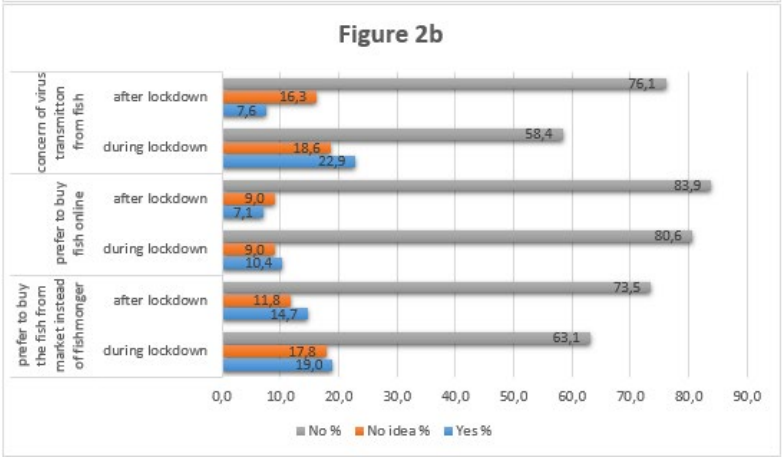




**Figure 2.** Virus-related concerns and change in purchasing preferences (a) Food, (b) fish

## Results and Discussion

### *The Effect of the Pandemic on Food and Fish Consumption*

Despite its unpleasant effects, the pandemic has raised global awareness to change the food system to be more environmentally friendly, inclusive, sustainable, and resistant (Ruiz-Salmón et al., 2021). The vulnerability of the global food system was exposed during the pandemic. Thus, the importance of creating food systems that will be more resilient to future pandemics or other shocks was recognised (O'meara et al., 2022). Increasing awareness and demand for food supply and safety worldwide will inevitably lead to lasting changes in the food sector (Güney et al., 2020). The lockdowns, restrictions, and social and psychological factors affected individuals' dietary habits (Caso et al., 2022). While some studies have shown an increase in the consumption of unhealthy or junk food (Sanchez-Sanchez et al., 2020; Cavagnari et al., 2022), others have reported a trend toward the consumption of healthy foods such as fish (Perez-Rodrigo et al., 2020). This study reveals a statistically significant difference in food consumption during and after the lockdowns ($p$-value < 0.05). Most respondents (58%) stated they consumed more food during the lockdowns than before (Figure 1). After the lockdowns, the proportion of this response was 29%, indicating that consuming too much food did not turn into a habit. However, the situation was different for fish consumption. There is no statistically significant difference in fish consumption during and after the lockdowns ($p$-value > 0.05). More than 60% of respondents (Figure 1) said they did not eat more fish during or after the lockdowns. Therefore, they have consistently stated that they have not increased fish consumption compared to before the pandemic. However, fish have been reported to be one of the antiviral functional foods to cope with coronavirus (Alkhatib, 2020), and increased fish intake is recommended for high-risk individuals. Pardo (2020) used nutritional support containing fish oil to cure critical patients infected with SARS-CoV-2. Likewise, Yu et al. (2021) identified tuna protein peptides as possible SARS-CoV-2 inhibitors. In our survey, the respondents stated that they think consuming fish could help to protect against the virus. The proportion of respondents who thought eating fish could protect against the virus (during lockdowns, 38.8%) increased even more after the lockdowns (57.1%). It can be said that the idea about the benefit of fish consumption increased in the later stages of the pandemic. However, this idea did not lead to an increase in fish consumption during the pandemic. The consumer tended to eat more fish in many countries, considering its health benefits. Portuguese consumers reported increased consumption of foods such as fish and vegetables and decreased consumption of ready foods and snacks, as they tend to buy healthier foods to protect themselves from coronavirus (Martins et al., 2022). Similarly, Palestinian students' fish consumption increased during the pandemic (Radwan et al., 2021). Revoredo-Giha & Russo (2020) studied the effect of the COVID-19 pandemic on British consumers and noted that the pandemic led to an increase in meat and fish purchases. In a survey conducted in Bangladesh, 72.8% of respondents reported consuming more fish during the pandemic due to its health benefits, and 95% also reported that they liked eating fish in general (Kashem et al., 2021). On the other hand, in a survey conducted in Türkiye, 66% of the participants stated that the pandemic did not change their fish consumption, similar to our findings (Haskaraca et al., 2021). Kartari et al. (2021) even reported a decreased fish consumption in Türkiye during the pandemic. This may be because fish consumption in Türkiye is relatively low, 6.7 kg per capita (Anon, 2021), compared to many other countries. Dietary habits may have played a role in participants not consuming more fish, although they thought eating fish would help protect against the virus's effects. The pandemic has also reduced fish consumption in Congo (Manyong et al., 2022) and ten countries in East and Southern Africa (Nchanji & Lutomia, 2021). Similarly, Di Renzo et al. (2020) reported decreased fish consumption in Italy. They stated that limited daily shopping may be a reason for the reduced demand for perishable fresh foods such as fish. This statement is supported by Belton et al. (2021) for seafood consumption in Africa and Asia.

A notable pandemic effect is the increased preference for eating at home (Filimonau et al., 2022). Consumers have started to cook at home kitchen more than ever. Galanakis (2023) noted that the closure of restaurants and the increased home cooking could lead to a lasting change in attitudes towards food. Likewise, Revoredo-Giha & Russo (2020) reported substituting restaurants and catering food services with at-home consumption during the pandemic and reported reduced intake of meat and fish due to the effects of the pandemic. In this study, participants were asked whether they reduced the consumption of some foods due to the closure of restaurants during the pandemic, and fish was found to be the most affected food. Most (58%) respondents reported decreased fish consumption since they could not eat it out (Figure 3). It has been reported that the closure of restaurants during the pandemic significantly impacted fish consumption (Love et al., 2021), and the fish sector has been negatively affected by the drastic decline in out-of-home food consumption (Pititto et al., 2021). In the present study, although ≥50% of respondents reported decreased consumption of bakery and red meat due to the closure of restaurants, they also reported that they started to cook bakery products at home more than ever. However, a few respondents (<20%) preferred to cook fish and red meat at home. Consumers preferred to cook

vegetable-fruit, bakery, and grain-legume at home during the pandemic and used chicken as animal protein (Figure 3). Similarly, Mandal et al. (2021) reported increased vegetable consumption in Bangladesh, and dried fish, poultry, lentils, and eggs have replaced fish consumption. It was reported that the Italian consumer consumed less fish but more homemade food, vegetables, and poultry during the pandemic (Di Renzo et al., 2020). The fact that some consumers do not prefer or find it difficult to cook fish at home may have led them to prefer easier (and often cheaper) alternatives to fish (Pititto et al., 2021).

As food intake is essential not only for individuals but also at the national and global levels (Martins et al., 2022), it is essential to identify the food-related impacts of the pandemic. Changes in food intake patterns can determine global food trade and many industries, such as agriculture, livestock, fisheries, and food processing.

### *Tendency to Packaged Food and Online Shopping Due to Virus Concerns*

It is globally known that the Covid-19 pandemic started in the Wuhan seafood market in China. The virus was isolated from fish cutting boards, and the fish trade was drastically reduced. Fish scientists had to defend against public concerns about fish consumption (Abbadi., 2020). Although scientific studies report that SARS-CoV-2 does not affect or contaminate seafood (Bondad-Reantaso et al., 2020), worldwide disinformation has led to consumer concern about the transmission of the virus through fish consumption (Genc et al., 2020). The fact that the COVID-19 pandemic was first detected in seafood and animal markets also created a perception against seafood in the minds of consumers, and consumers in some regions avoided fish and seafood consumption during the pandemic (Kartari et al., 2021).

In this study, there is a significant statistical difference between concerns about the transmission of the virus from food and seafood ($p$-value<0.05). This can be followed through Figure 2a and Figure 2b. It was found that the participants were concerned about virus transmission from food, mainly during lockdowns (58%) (Figure 2a), but a few were concerned about virus transmission from fish (Figure 2b). Indeed, the correlation between fish consumption and the worldwide incidence of COVID-19 (0.089573896) is very weak, and the assumption that COVID-19 is a zoonotic disease does not seem appropriate for fish (Abbadi, 2020). Bondad-Reantaso et al. (2020) stated that SARS-CoV-2 belongs to the Coronaviridae family, genus Betacoronavirus, and Betacoronaviruses are not known to infest nor infect seafood; instead, they infect mammals. They noted that fish surfaces, like any other surface, can be contaminated with SARS-CoV-2 when handled by infected individuals. Therefore, they emphasised that the likelihood of SARS-CoV-2 transmission is negligible with proper food handling and sanitation. Since SARS-CoV-2 can be isolated from frozen foods, storage, and packaging materials, it can remain highly stable on fish or meat under cold and frozen storage conditions. Therefore, policies and risk mitigation strategies must be established to prevent food contamination (Han et al., 2021).

In the present study, respondents (56.9% during and 45.5% after lockdowns) indicated that they preferred to buy food online (Figure 2a) and packaged (53.7% during, 39.2% after lockdowns). Consumers worldwide have experienced changes in their food supply during the COVID-19 pandemic due to restrictions and/or fear of contamination (Dumitras et al., 2021). The packed food become crucial due to the pandemic. The necessity of hygiene and the importance of packaging to preserve foods from contamination became priorities for the consumer. The consumer considered packaged foods safe because they were protected by a package that guaranteed product hygiene. A study with Turkish consumers reported that packaged foods were primarily preferred (79.3%) during the Covid-19 pandemic (Cosansu et al., 2022). Following the COVID-19 pandemic, 34% of consumers stated that hygienic packaging is one of the main criteria when purchasing food (Timpanaro & Cascone, 2022). One of the essential food-related impacts of the Covid-19 pandemic is the consumer's tendency to buy food online. Food orders have shifted online in many countries, depending on the countries' digital development level. In Qatar and the United Arab Emirates, online food shopping increased by 30% compared to before the COVID-19 pandemic (Faour-Klingbeil et al., 2021). Due to the pandemic, Italian consumers have also increased online food shopping (Cavallo et al., 2020). Güney et al. (2020) reported that Turkish consumers are concerned about virus transmission during shopping in the market and tend to buy food online. Regarding buying fish, it was determined that the respondents did not prefer to buy fish online or from the market and continued to buy fish from the fishmonger (Figure 2b). Especially in terms of online shopping, the majority of the participants (>80%) stated that they do not prefer to buy fish online.

Figure 4 shows the responses to the questions about the possible effects of freshness concerns on online fish shopping. The effect of freshness concerns on the consumer's approach to online fish shopping is presented in Figure 4. It is determined that 62.16% of the participants are concerned that the fish ordered online may spoil until it arrives, and 71.18% are concerned that stale fish will be sent when ordered online. Concern about freshness is an important reason to avoid ordering fish online. Similarly, a study examining the impact

of the pandemic on meat consumption in Türkiye reported that respondents were concerned about spoilage when ordering online (Haskaraca et al., 2021).

The effect of demographic variables (gender, age, education, income) on concerns related to online fish orders has been examined using the non-parametric Kruskal-Wallis test. The obtained results are summarised in Table 2. There is a statistically significant difference in age, education and income ($p$-value <0.05) for fish spoilage until it arrives in online shopping. Regarding concerns about being sent stale fish in online shopping, there is a significant difference only in terms of education ($p$-value < 0.05). There is no significant difference in other variables such as gender, age, and income ($p$-value > 0.05). For online fish ordering, the concern that the fish might spoil until it arrives is lower among the younger age, higher education, and higher income groups. Similarly, highly educated respondents are the least concerned about sending stale fish when they order fish online (Table 2). Examining the "mean rank" column in Table 2 can also interpret these results. It has also been reported that education level is an influential factor in consumer attitude towards food during the pandemic (Rodríguez-Pérez et al., 2020). It has been observed that gender does not create a statistically significant difference for both concerns.

***Food Insecurity***

Lack of regular access to safe and nutritious food for a healthy life is referred to as food insecurity. It may be experienced at different levels, such as the lack of regular access to sufficient and safe food and/or lack of resources to obtain food FAO (2023). COVID-19 has threatened food insecurity by restricting access to and availability, leading to instability in food prices and a shift to less nutritious foods (Laborde et al., 2020). The COVID-19 outbreak has caused millions to experience food insecurity in Congo and has threatened the country's progress toward Sustainable Development Goal 2 (SDG2) (Manyong et al., 2022). The pandemic has more impact than a worldwide disease, including socioeconomic and food security, and its effects on food security are not yet apparent (Elsahoryi et al., 2020). In this study, 49.6% of the respondents declared they were concerned about food shortage during the lockdowns (Figure 5), which shows that they experienced food insecurity. Ahmed et al. (2021) similarly reported food insecurity among households in Bangladesh during the Covid-19 pandemic. In Jordan, around 60% of the population was reported to have experienced moderate or severe food insecurity during the pandemic (Elsahoryi et al., 2020). Food-insecure households have been much more affected by the COVID-19 pandemic due to their lack of access to healthy food (Kent et al., 2022). The pandemic has made everyone realise the undeniable importance of food security and nutrition (Galanakis, 2023). The need for large-scale sustainability policies to ensure food and nutrition security is recognised (Mandal et al., 2021).

**Table 2.** Kruskal Wallis Test Results for Socio-demographic variables (n= 510)

| | | If I order online, I think the fish may spoil until it arrives | | | if I order online, I think they will send stale fish | | |
|---|---|---|---|---|---|---|---|
| **VARIABLES** | **Category** | **Mean Rank** | **Chi-Square** | **p-value** | **Mean Rank** | **Chi-Square** | **p-value** |
| **Gender** | Male | 263.34 | 2.145 | .342 | 257.86 | .399 | .819 |
| | Female | 248.13 | | | 253.46 | | |
| | Not prefer to say | 203.75 | | | 216.75 | | |
| **Age** | <26 | 225.58 | 10.536 | .005 | 235.44 | 5.620 | .060 |
| | 26 - 40 | 265.01 | | | 261.43 | | |
| | >40 | 268.65 | | | 264.90 | | |
| **Education** | Primary education | 312.13 | 64.139 | .000 | 293.24 | 25.585 | .000 |
| | Secondary education | 272.43 | | | 257.17 | | |
| | Higher education | 205.11 | | | 228.99 | | |
| **Monthly income** | <341 $ - | 254.58 | 7.871 | .049 | 267.49 | 4.503 | .212 |
| | 341 $ - 682 $ | 259.55 | | | 253.98 | | |
| | 683 $ - 1365 $ | 265.00 | | | 258.93 | | |
| | >1365 $ | 204.79 | | | 223.15 | | |

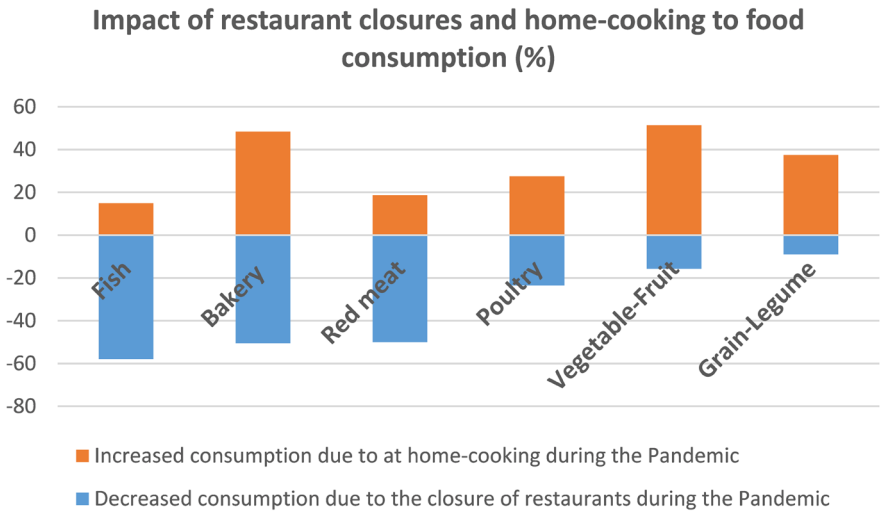



**Figure 3.** Impact of restaurant closures and home-cooking to food consumption (%)

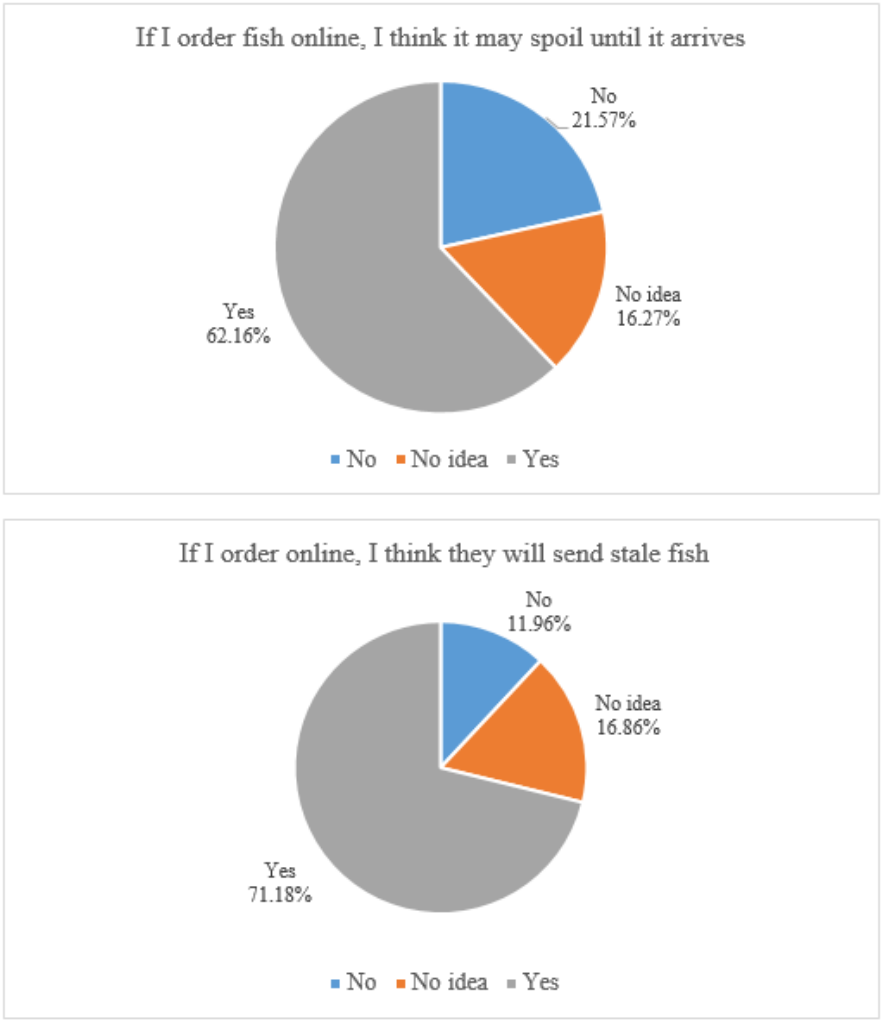



**Figure 4.** The possible effects of freshness concerns on online fish shopping

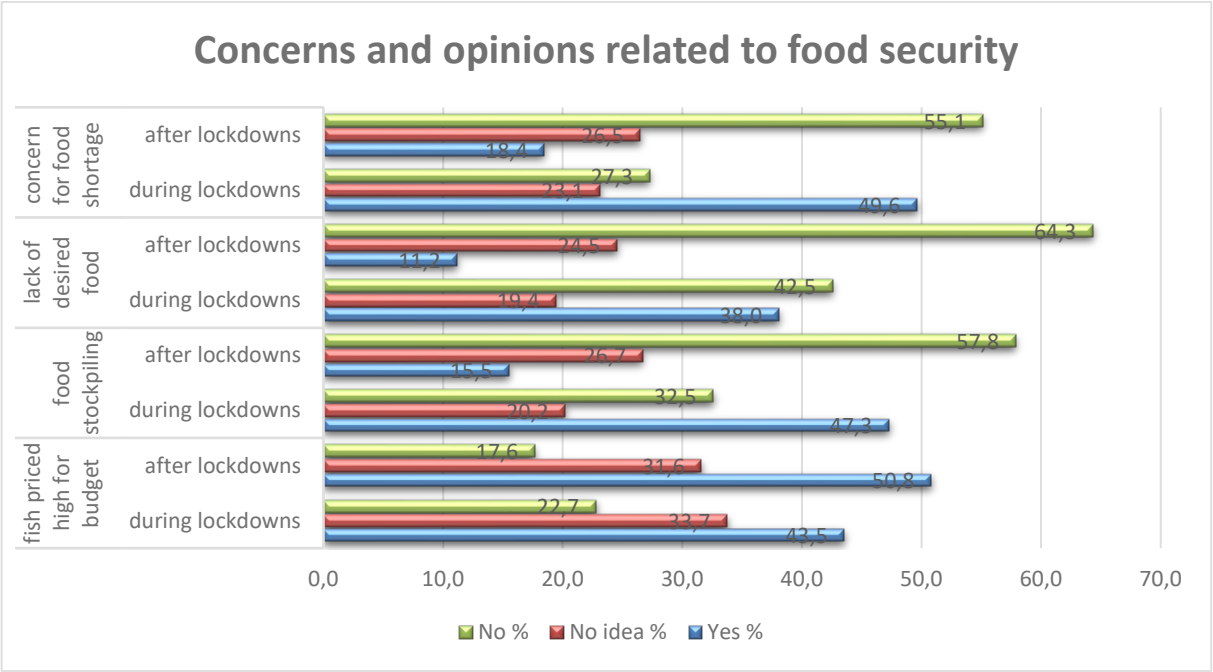



**Figure 5.** Concerns and opinions related to food security

Changed conditions during the pandemic led to concerns about food supply, and many people realised that food availability is the primary need (Güney et al., 2020). As presented in Figure 5, although some respondents (38%) experienced a lack of desired food during the lockdowns, most (64.3%) reported no problems during the following period. In a similar study conducted in Indonesia, participants reported that some foods, such as fish, were unavailable as before during the pandemic (Partelow et al., 2023). Zhang et al. (2021) examined the impacts of the COVID-19 outbreak on the seafood trade in China, which has a critical position and influence in the seafood trade. They suggested improving domestic regulations and increasing international cooperation to minimise the impact of such crises and ensure food supply. This crisis has revealed the necessity of establishing a more sustainable food system in the coming years (Cavallo et al., 2020).

Revoredo-Giha & Russo (2020) stated that the COVID-19 pandemic caused an unprecedented shock to British consumers, especially for meat and fish chains. They stated that the pandemic led to fears of future shortages and a tendency to stockpile. Respondents of this survey stated that they tended to stock food (47.3%) during the lockdowns but did not continue to do so (57.8%). It shows that food stockpiling has not become a habit (Figure 5). Akdemir et al. (2020) also reported that Turkish consumers' food stocking increased after the Covid-19 pandemic. Ahmed et al. (2021) examined the effects of the pandemic on food insecurity in Bangladesh and reported that households rely on food stocks to cope with the food crisis. Indeed, half of the Bangladeshi households stockpiled long-lasting foods such as rice, lentils, and potatoes during the pandemic (Mandal et al., 2021). On the other hand, in a survey conducted in Russia, more than 70% of respondents stated that they bought more than usual each shopping but did not stock food (Hassen et al., 2021).

The increased food prices have been one of the other important issues of the pandemic. The decrease in export volumes has affected the fish supply chain, making it more challenging to access fish and increasing prices (Mandal et al., 2021). In this study, 43.5% of respondents reported that fish prices were high for their budget during the lockdowns. The number of respondents reporting high fish prices (50.8%) increased further in the later stages of the pandemic (Figure 5). In a survey conducted in Bangladesh, 72% of respondents stated that the pandemic had increased fish prices, similar to the present study. The Covid-19 pandemic led to a 5.3% drop in global trade volume (WTO, 2023). Love et al. (2021) studied the impacts of COVID-19 on the seafood trade to build resilience in the seafood system and proposed immediate and long-term research to guide strategic investments**.** Actions such as the supply of ready-to-cook or processed seafood, online fish delivery, and implementation of adequate cold storage in fish production areas are the policies that governments should pay more attention to in the case of future pandemics (Mitra et al., 2022). The COVID-19 pandemic has revealed the importance of technologies enabling the food industry to prepare for future epidemics and pandemics by ensuring food safety and a safe supply chain (Han et al., 2021).

Nchanji & Lutomia (2021) emphasised that the pandemic offers essential lessons in restructuring food supply systems for sustainability in the future and proposed short food supply chains, inclusive legal support instruments, and economic partnerships among countries as policy interventions for sustainable production and consumption. It should be a critical priority for governments and all stakeholders to understand the experiences of communities with food insecurity during the COVID-19 pandemic and to develop tailored policies to respond to future shocks that may affect population nutrition (Zorbas et al., 2023).

## *Conclusion*

The COVID-19 pandemic has highlighted the importance of systems and technologies that will enable the food industry to prepare for future shocks. This study reveals behavioural changes and opinions on fish and food consumption during the Covid-19 pandemic. It provides a perspective on the changes the pandemic may cause in future consumption patterns and purchasing behaviours (Figure 6). Since the coronavirus was first detected in the Wuhan fish market, it may raise concerns about fish consumption in various communities. For this reason, it is essential to examine the effect of the pandemic on opinions and behaviours related to fish consumption and other foods. During the pandemic, Turkish consumers increased their food consumption, tended to packaged and stocked food, and were concerned about food shortage and potential virus contamination from food. Although they think that eating more fish may help protect against the virus and they are not worried that the virus will be transmitted from the fish, they did not tend to consume more fish and stated that the fish prices are high for their budget. Although they increased online food shopping, they did not prefer online fish shopping for freshness concerns. Our findings are helpful for the local and international fish trade. They will provide information for fish producers, fishermen, suppliers, processors, and retailers to create healthy, sustainable food environments more resilient to future shocks.

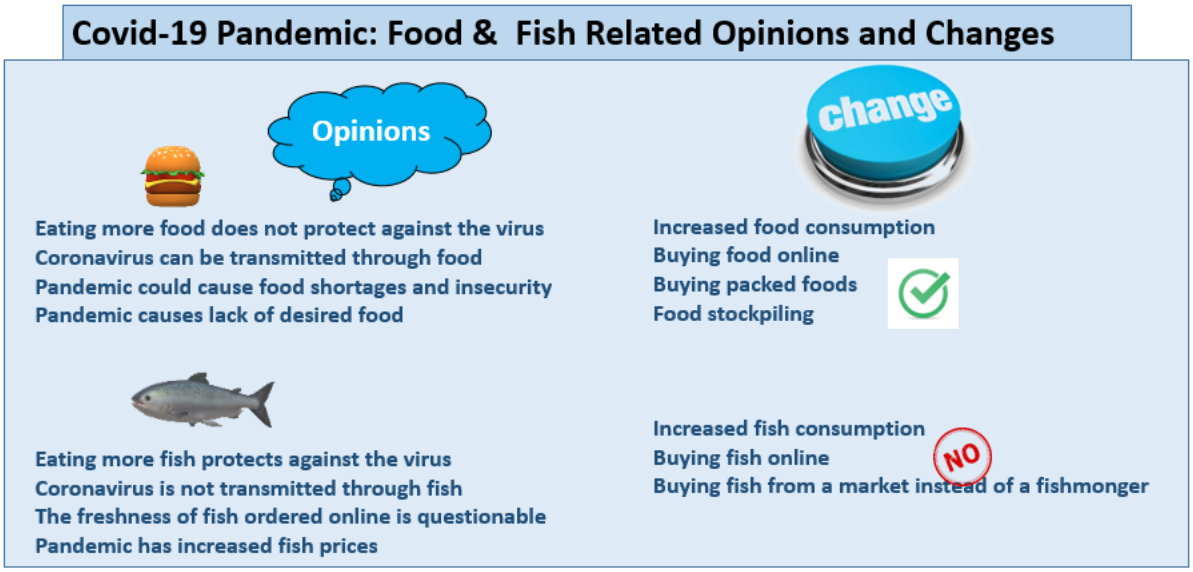



**Figure 6.** Behavioral changes and opinions on fish and food consumption due to the COVID-19 Pandemic

**Compliance with Ethical Standards**

**Conflict of interest:** The authors declare no actual, potential, or perceived conflict of interest for this article.

**Ethics committee approval:** The survey titled "The Effect of Covid-19 Pandemic on the Consumption of Seafood and Other Foods" with file number 2022/106 was discussed at the Istanbul University Social and Human Sciences Research Ethics Committee meeting dated 30.05.2022 and numbered 06 and found ethically appropriate. Verification code: BSRSPLA6E3 Pin code: 25652 Document tracking address: https://www.turkiye.gov.tr/istanbul-universitesi-ebys Approval no: E-35980450-663.05-952818

**Data availability:** Data will be made available on request.

**Funding disclosure:** No funding provided.

**Acknowledgements:** -

**Disclosure:** -

## References

**Abbadi, O.S. (2020).** The correlation between fish consumption and the incidence of COVID-19 infection worldwide. *Chinese Journal of Medical Research,* 3 (3), 74-76. https://doi.org/10.37515/cjmr.091X.3303

**Ahmed, F., Islam, A., Pakrashi, D., Rahman, T., Siddique, A. (2021).** Determinants and dynamics of food insecurity during COVID-19 in rural Bangladesh. *Food Policy,* 101, 102066. https://doi.org/10.1016/j.foodpol.2021.102066

**Akdemir, S., Kougnigan, E., Keskin, F., Açıksarı, Y., Miassi, Y. (2020).** Effects of Covid-19 on food consumption habits in Turkey. International Conference on Covid-19 Studies. June 21-23, Ankara, 812.

**Alkhatib, A. (2020).** Antiviral functional foods and exercise lifestyle prevention of coronavirus. *Nutrients,* 12,2633. https://doi.org/10.3390/nu12092633

**Anon (2021)**. *Su Ürünleri İstatistikleri* Tarım ve Orman Bakanlığı Balıkçılık ve Su Ürünleri Genel Müdürlüğü Ankara.

**Belton, B., Rosen, L., Middleton, L., Ghazali, S., Al Mamun, A., Shieh, J., Noronha, H.S., Dhar, G., Ilyas, M., Price, C., Nasr-Allah, A., Elsira, I., Baliarsingh, B.K., Padiyar, A., Rajendran, S., Mohan, A.B.C., Babu, R., Akester, M. J., Phyo, E.E., Soe, K.M., Olaniyi, A., Siriwardena, S.N., Bostock, J., Little, D.C., Phillips, M., Thilsted, S.H (2021).** COVID-19 impacts and adaptations in Asia and Africa's aquatic food value chains. Marine *Policy,* 129, 104523. https://doi.org/10.1016/j.marpol.2021.104523

**Bondad-Reantaso, M.G., Mackinnon, B., Bin, H., Jie, H., Tang-Nelson, K., Surachetpong. W., Alday-Sanz, V., Salman, M., Brun, E., Karunasagar, I., Hanson, L., Sumptıon, K., Barange, M., Lovatelli, A., Sunarto, A., Fejzic, N., Subasinghe, R., Mathiesen, A.M., Shariff, M (2020).** Viewpoint: SARS-CoV-2 (The cause of COVID-19 in humans) is not known to infect aquatic food animals nor contaminate their products. *Asian Fisheries Science.* 33, 74 -78. https://doi.org/10.33997/j.afs.2020.33.1.009

**Caso, D., Guidetti, M., Capasso, M., Cavazza, N. (2022).** Finally, the chance to eat healthily: Longitudinal study about food consumption during and after the first COVID-19 lockdown in Italy. *Food Quality and Preference,* 95, 104275. https://doi.org/10.1016/j.foodqual.2021.104275

**Cavagnari, B.M., Vinueza-Veloz, M.F., Carpio-Arias, V., Durán-Agüero, S., Ríos-Castillo, I., Nava-González, E.J., Pérez-Armijo, P., Camacho-López, S., Mauricio-Alza, S., Bejarano-Roncancio, J. J., Núñez-Martínez, B., González-Medina, G., Ivankovich-Guillén, S., Ortíz, A., Cordón-Arrivillaga, K., Meza-Miranda, E. R., Landaeta-Díaz, L. (2022).** Bodyweight change and its association with food and beverage consumption at the beginning COVID-19 confinement. *Clinical Nutrition ESPEN,* 52, 436-444. https://doi.org/10.1016/j.clnesp.2022.09.025

**Cavallo, C., Sacchi, G., Carfora, V. (2020).** Resilience effects in food consumption behavior at the time of Covid-19: perspectives from Italy. *Heliyon,* 6(12), e05676. https://doi.org/10.1016/j.heliyon.2020.e05676

**Cosansu, S., Başyazıcı, E., Atasoy, E., Mazreku, G., Çetin, S., Toupal, S. (2022)**. COVID-19 salgınında tüketicilerin gıda satın alma, gıda hijyeni ve beslenme davranışları. *Food and Health*, 8(4), 302-311. https://doi.org/10.3153/FH22028

**Cranfield, J.A.L. (2020).** Framing consumer food demand responses in a viral pandemic, *Canadian Journal of Agricultural Economics,* 68(2), 151-156. https://doi.org/*10.1111/cjag.12246*

**Di Renzo, L., Gualtieri, P., Pivari, F., Soldati, L., Attinà, A., Cinelli, G., Leggeri, C., Caparello, G., Barrea, L.,**

**Scerbo, F., Esposito, E., De Lorenzo, A. (2020).** Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. *Journal of Translational Medicine,* 18, 229. *https*://doi.org/10.1186/s12967-020-02399-5

**Dumitras, D.E., Harun, R., Arion, F.H., Chiciudean, D.I., Kovacs, E. Oroian, C.F., Porutiu, A., Muresan, I. C. (2021).** Food Consumption Patterns in Romania during the COVID-19 Pandemic. *Foods,* 10, 2712. https://doi.org/10.3390/foods10112712

**Elsahoryi, N., Al-Sayyed, H., Odeh, M., McGrattan, A., Hammad, F. (2020).** Effect of Covid-19 on food security: A cross-sectional survey. *Clinical Nutrition ESPEN,* 40,171-178. https://doi.org/10.1016/j.clnesp.2020.09.026

**FAO (2023).** Hunger and food insecurity. https://www.fao.org/hunger/en (accessed 20.07.2023).

**Faour-Klingbeil, D., Osaili, T.M., Al-Nabulsi, A.A., Jemni, M., Todd, E.C.D. (2021).** An on-line survey of the behavioral changes in Lebanon, Jordan and Tunisia during the COVID-19 pandemic related to food shopping, food handling, and hygienic practices. *Food Control,* 125, 107934. https://doi.org/10.1016/j.foodcont.2021.107934

**Filimonau, V., Vi, L.H., Beer, S., Ermolaev, V.A. (2022).** The Covid-19 pandemic and food consumption at home and away: An exploratory study of English households. *Socio-Economic Planning Sciences* Part A, 82, 101125. https://doi.org/10.1016/j.seps.2021.101125.

**Galanakis, C. M. (2023).** The "Vertigo" of the Food Sector within the Triangle of Climate Change, the Post-Pandemic World, and the Russian-Ukrainian War. *Foods,* 12, 721. https://doi.org/10.3390/foods12040721

**Genc, E., Kaya, D., Atalay, M. A., Kanyılmaz, M. (2020).** Effects of Covid-19 Pandemic on the Fisheries and Aquaculture Industry: A Mini Review. *Türkiye Biyoetik Dergisi,* 7(3), 162-167. https://doi.org/10.5505/tjob.2020.06025

**Güney, O. I., Sangün, L. (2020).** How COVID-19 affects individuals' food consumption behaviour: a consumer survey on attitudes and habits in Turkey. *British Food Journal,* 123: 7, 2307-2320. https://doi.org/10.1108/BFJ-10-2020-0949

**Han, J., Zhang, X., He, S., Jia, P (2021).** Can the coronavirus disease be transmitted from food? A review of evidence, risks, policies and knowledge gaps. *Environmental Chemistry Letters,* 19, 5-16. https://doi.org/10.1007/s10311-020-01101-x

**Haskaraca, g., Bostanci, E., Arslan, Y. (2021).** Effects of the COVID-19 Pandemic on eating and meat consumption habits of Turkish adults. *Turkish Journal of Agriculture - Food Science and Technology,* 9(1), 63-69. https://doi.org/10.24925/turjaf.v9i1.63-69.3704

**Hassen, T.B., El Bilali, H., Allahyari, M.S., Berjan, S., Fotina, O. (2021).** Food purchase and eating behavior during the COVID-19 pandemic: A cross-sectional survey of Russian adults. *Appetite*, 165, 105309. https://doi.org/10.1016/j.appet.2021.105309

**Kartari, A., Özen, A.E., Correia, A.C. Wen, J., Kozak, M. (2021).** Impacts of COVID-19 on changing patterns of household food consumption: An intercultural study of three countries. *International Journal of Gastronomy and Food Science,* 26, 100420. https://doi.org/10.1016/j.ijgfs.2021.100420

**Kashem, A., Tasnim, N., Mahmudur, R., Bapary, M.A.J., Abdullah, A. (2021).** Consumer's attitudes toward fish consumption during pandemic Covid-19 in Bangladesh. *International Journal of Natural Sciences*, 11, 15-22. https://doi.org/10.5539/ibr.v15n8p44

**Kent, K., Murray, S., Penrose, B., Auckland, S., Godrich, S., Lester, E., Visentin, D. (2022).** Food insecure households faced greater challenges putting healthy food on the table during the COVID-19 pandemic in Australia. *Appetite,* 169, 105815. https://doi.org/10.1016/j.appet.2021.105815

**Laborde, D., Martin, W., Swinnen, J. & Vos, R (2020).** COVID-19 risks to global food security. *Science,* 369(6503), 500-502. https://doi.org/10.1126/science.abc4765

**Love, D.C., Allison, E.H., Asche, F., Belton, B., Cottrell, R.S., Froehlich, H. E., Gephart, J. A., Hicks, C. C., Little, D. C., Nussbaumer, E. M., da Silva, P. P., Poulain, F., Rubio, A., Stoll, J. S., Tlusty, M. F., Thorne-Lyman, A. L., Troell, M., Zhang,W. (2021).** Emerging COVID-19 impacts, responses, and lessons for resilience in the seafood system. *Global Food Security,* 28, 100494. https://doi.org/10.1016/j.gfs.2021.100494

**Mandal, S.C., Boidya, P., Haque, M.I., Hossain, A., Shams, Z., Mamun, A. (2021).** The impact of the COVID-19 pandemic on fish consumption and household food security in Dhaka city, Bangladesh. *Global Food Security,* 29, 100526.
https://doi.org/10.1016/j.gfs.2021.100526

**Manyong, V., Bokanga, M., Nyamuhirwa, D.A., Bamba, Z., Adeoti, R., Mwepu, G., Cole, S.M., Nguezet, P.M.D. (2022).** COVID-19 outbreak and rural household food security in the Western Democratic Republic of the Congo. *World Development Perspectives,* 28, 100469.
https://doi.org/10.1016/j.wdp.2022.100469

**Martins, R., Capitão, C., Fialho, M., Feteira-Santos, R., Virgolino, A., Santos, R.R., Alarcão, V., Silva, M., Arriaga, M., Graça, P., Gregório, M.J., Santos, O. (2022).** Are beliefs and attitudes about COVID-19 associated with self-perceived changes in food consumption? Results from a nationwide survey during lockdown. *Appetite,* 168, 105681.
https://doi.org/10.1016/j.appet.2021.105681

**Ministry of Interior (2021a).** 81 İl Valiliğine Kısmi Kapanma Genelgesi Gönderildi, 14.04.2021
https://www.icisleri.gov.tr/81-il-valiligine-kismi-kapanma-genelgesi-gonderildi/ (accessed 01.06.2023).

**Ministry of Interior (2021b).** 81 İl Valiliğine Tam Kapanma Tedbirleri Genelgesi Gönderildi, 26.04.2021
https://www.icisleri.gov.tr/81-il-valiligine-tam-kapanma-tedbirleri-genelgesi-gonderildi (accessed 01.06.2023).

**Ministry of Interior (2021c).** 81 İl Valiliğine Kademeli Normalleşme Tedbirleri Genelgesi Gönderildi, 27.06.2021
https://www.icisleri.gov.tr/81-il-valiligine-kademeli-normallesme-tedbirleri-genelgesi-gonderildi/
(accessed 01.06.2023).

**Mitra, S., Prodhan, M.H., Khatun, K.L., Khan, A., Acharjee, D.C. (2022).** Impact of COVID-19 on fish consumers: Market price, expenditure, and satisfaction perspective. *Journal of Agriculture and Food Research,* 10, 100413.
https://doi.org/10.1016/j.jafr.2022.100413

**Nchanji, E.B., Lutomia, C.K. (2021).** COVID-19 challenges to sustainable food production and consumption: Future lessons for food systems in eastern and southern Africa from a gender lens. *Sustainable Production and Consumption,* 27, 2208-2220.
https://doi.org/10.1016/j.spc.2021.05.016

**Noy, C. (2008).** Sampling Knowledge: The Hermeneutics of Snowball Sampling in Qualitative Research. *International Journal of Social Research Methodology,* 11(4),327-344.
https://doi.org/10.1080/13645570701401305

**O'Meara, L., Turner, C., Coitinho, D.C., Oenema, S. (2022).** Consumer experiences of food environments during the Covid-19 pandemic: Global insights from a rapid online survey of individuals from 119 countries. *Global Food Security,* 32, 100594.
https://doi.org/10.1016/j.gfs.2021.100594

**Pardo, E. (2020).** Nutritional support for critically ill patients suffering from SARS-CoV-2 infection. *Europe PMC,* 24, 218-224.
https://doi.org/10.1016/j.pratan.2020.07.002

**Partelow, S., NAgel, B., Paramita, A.O., Buhari, N. (2023).** Seafood consumption changes and COVID-19 impact index in West Nusa Tenggara, Indonesia. *Plos One,* 18, 1-22.
https://doi.org/10.1371/journal.pone.0280134

**Pérez-Rodrigo, C., Citores, M.G., Bárbara, G.H., Litago, F.R., Sáenz, L.C., Aranceta- Bartrina, J.M. (2020).** Cambios en los hábitos alimentarios durante el periodo de confinamiento por la pandemia COVID-19 en España. *Revista Española de Nutrición Comunitaria,* 26(2).
https://doi.org/10.14642/RENC.2020.26.2.5213

**Pititto, A., Rainone, D., Sannıno, V., Chever, T., Herry, L., Parant, S., Souıdı, S., Ballesteros, M., Chapela, R., L. Santago, J. (2021).** Impacts of the COVID-19 pandemic on EU fisheries and aquaculture Policy Department for Structural and Cohesion Policies. Directorate-General for Internal Policies. PE 690.880 - July 2021.
https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690880/IPOL_STU(2021)690880_EN.pdf (accessed 20.07.2023).

**Pulighe, G., Lupia, F. (2020).** Food first: COVID-19 outbreak and cities lockdown a booster for a wider vision on urban agriculture. *Sustainability,* 12(5012), 1-4.
https://doi.org/10.3390/su12125012

**Radwan, A., Radwan, E., Radwan, W. (2021).** Eating habits among primary and secondary school students in the Gaza Strip, Palestine: A cross-sectional study during the COVID-19 pandemic. *Appetite,* 163, 105222.
https://doi.org/10.1016/j.appet.2021.105222

**Revoredo-Giha, C., Russo, C. (2020).** Purchases of Meats and Fish in Great Britain During the COVID-19 lockdown Period. *Frontiers in Nutrition,* 8, 648160 https://doi.org/10.3389/fnut.2021.648160

**Rodríguez-Pérez, C., Molina-Montes, E., Verardo, V., Artacho, R., García-Villanova, B., Guerra-Hernández, E.J., Ruíz-López, M.D. (2020).** Changes in Dietary Behaviours during the COVID-19 Outbreak Confinement in the Spanish COVIDiet Study. *Nutrients*, *12,* 1730. https://doi.org/10.3390/nu12061730

**Ruiz-Salmón, I., Fernández-Ríos, A., Campos, C., Laso, J., Margallo, M., Aldaco, R. (2021).** The fishing and seafood sector in the time of COVID-19: Considerations for local and global opportunities and responses. *Current Opinion in Environmental Science & Health.* 23:100286. https://doi.org/10.1016/j.coesh.2021.100286

**Sağlık Bakanlığı (2023).** COVID-19 Nedir? https://covid19.saglik.gov.tr/TR-66300/covid-19-nedir-.html (accessed 20.07.2023).

**Sanchez-Sanchez, E., Ramírez-Vargas, G., Avellaneda-L´opez, Y., Orellana-Pecino, J.I., García-Marín, E., Díaz-Jimenez, J. (2020).** Eating habits and physical activity of the Spanish population during the COVID-19 pandemic period. *Nutrients,* 12(9), 2826. https://doi.org/10.3390/nu12092826

**TCMB (2023).** Indicative Exchange Rates Announced at 15:30 on 04/01/2022 by the Central Bank of Turkey https://www.tcmb.gov.tr/kurlar/202204/01042022.xml (accessed 20.07.2023).

**Timpanaro, G., Cascone, G. (2022).** Food consumption and the Covid-19 pandemic: The role of sustainability in purchasing choices. *Journal of Agriculture and Food Research,* 10, 100385. https://doi.org/10.1016/j.jafr.2022.100385

**Turkish Statistical Institute (2022a).** Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları, 2022 SAYI: 49685 https://data.tuik.gov.tr/Bulten/Index?p=49685 (accessed 20.07.2023).

**Turkish Statistical Institute (2022b).** Hanehalkı Bilişim Teknolojileri Kullanım Araştırması, 2022, SAYI: 45587 https://data.tuik.gov.tr/Bulten/Index?p=Hanehalki-Bilisim-Teknolojileri-(BT)-Kullanim-Arastirmasi-2022-45587 (accessed 20.07.2023).

**UN (2020).** Shared responsibility, global solidarity: responding to the socioeconomic impacts of COVID-19. New York. https://unsdg.un.org/sites/default/files/2020-03/SG-Report-Socio-Economic-Impact-of-Covid19.pdf (accessed 20.07.2023).

**UN (2023).** News Global perspective Human stories World must be ready to respond to next pandemic: WHO chief https://news.un.org/en/story/2023/05/1136912 (accessed 20.07.2023).

**WHO (2023a).** Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020 https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed 20.07.2023).

**WHO (2023b).** Coronavirus disease (COVID-19) Weekly Epidemiological Updates and Monthly Operational Updates https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/ (accessed 20.07.2023).

**WHO (2023c).** Coronavirus disease (COVID-19): Herd immunity, lockdowns and COVID-19 https://www.who.int/news-room/questions-and-answers/item/herd-immunity-lockdowns-and-covid-19 (accessed 20.07.2023).

**WTO (2023).** Trade Falls Steeply in First Half of 2020, Press Release, https://www.wto.org/english/news_e/pres20_e/pr858_e.htm (accessed 20.07.2023).

**Yamane, T. (1967).** *Statistics: An Introductory Analysis*. 2nd Edition, Harper and Row, New York.

**Yu, Z., Kan, R., Ji, H., Wu, S., Zhao, W., Shuian, D., Liu, J., Li, J (2021).** Identification of tuna protein-derived peptides as potent SARS-CoV-2 inhibitors via molecular docking and molecular dynamic simulation. *Food Chemistry,* 342, 128366. https://doi.org/10.1016/j.foodchem.2020.128366

**Zhang, Y., Tang, Y., Zhang, Y., Sun, Y., Yang, H. (2021).** Impacts of the COVID-19 pandemic on fish trade and the coping strategies: An initial assessment from China's perspective. *Marine Policy,* 133, 104748. https://doi.org/10.1016/j.marpol.2021.104748

**Zorbas, C., Browne, J., Chung, A., Peeters, A., Booth, S., Pollard, C., Allender, S., Isaacs, A., Hawkes, C., Backholer, K. (2023).** Shifting the social determinants of food insecurity during the COVID-19 pandemic: the Australian experience. *Food Security,* 15(1), 151-170. https://doi.org/10.1007/s12571-022-01318-4

AQUATIC RESEARCH
E-ISSN 2618-6365
Aquatic Research 7(1), 30-38 (2024) • https://doi.org/10.3153/AR24004 Research Article

# Gemi kaynaklı deniz kirlenmesine hukuki bakış

**Aslıhan SEVİNÇ KUYUCU**

**Cite this article as:**
Sevinç Kuyucu, A. (2024). Gemi kaynaklı deniz kirlenmesine hukuki bakış. *Aquatic Research*, 7(1), 30-38. https://doi.org/10.3153/AR24004

İstanbul Üniversitesi Hukuk Fakültesi, Deniz Hukuku Anabilim Dalı, İstanbul, Türkiye

**ORCID IDs of the author(s):**
A.S.K. 0000-0001-8451-3417

**Submitted:** 12.10.2023
**Revision requested:** 26.10.2023
**Last revision received:** 29.10.2023
**Accepted:** 31.10.2023
**Published online:** 03.01.2024

**Correspondence:**
Aslıhan SEVİNÇ KUYUCU
**E-mail:** asevinck@istanbul.edu.tr



Available online at
http://aquatres.scientificwebjournals.com

## ÖZ

Deniz kirlenmesine sebep olan faktörlerin sayısı oldukça fazladır. Deniz kenarlarında ve denize yakın yerlerde bulunan şehirlerin atıkları, sanayi tesislerinin atıkları, insanlar tarafından denize bırakılan çöpler ve diğer atıklar bunlar arasındadır. Deniz kirlenmesine sebep olan bir diğer önemli faktör ise gemilerdir. Gemilerin denizde işletilmesi sırasında ortaya çıkan atıklar ile gemide kullanılan petrol ve türevlerinin denize karışması veya gemilerden başkaca zararlı maddelerin denize bırakılması ciddi boyutlarda deniz kirlenmesine sebep olabilmektedir. Kirlenmeden kaynaklanan sorumluluğa uygulanacak hükümler ise deniz kirliliğine sebep olan kirletici maddeye ve geminin türüne göre değişiklik göstermektedir. Hukukumuzda petrol ve türevleri dışındaki kirletici maddelerin sebep olduğu kirlenmeden kaynaklanan sorumluluk temel olarak 5312 sayılı "Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanun" da düzenlenmiştir. Öte yandan petrol ve türevlerinden kaynaklanan kirlenmeye ilişkin olarak iki uluslararası sözleşmeye taraf durumdayız. Bu sözleşmeler Petrol Kirliliğinden Doğan Zararın Hukukî Sorumluluğu İle İlgili Milletlerarası Sözleşme ve Gemi Yakıtlarından Kaynaklanan Petrol Kirliliği Zararının Hukuki Sorumluluğu Hakkında Milletlerarası Sözleşme'dir. Ayrıca 2872 Sayılı Çevre Kanunu da sayılan mevzuatın uygulama alanına girmeyen hâllerde deniz kirlenmesinden kaynaklanan sorumluluk hakkında uygulanır. Denizin gemi kaynaklı kirlenmesinden doğan hukuki sorumluluğa ilişkin düzenlemelerin caydırı etkisi sayesinde deniz kirlenmesi belli ölçüde engellenebilmektedir.

**Anahtar Kelimeler:** Deniz Kirlenmesi, 5312 Sayılı Kanun, Deniz Kirliliğinden Sorumluluk

## ABSTRACT

### Legal perspective on ship-related marine pollution

The number of factors that cause marine pollution is quite high. The wastes of cities located on the coasts or near the sea, wastes of industrial facilities, trashes left to the sea by people and other wastes are included in this content. Another important factor causing marine pollution is ships. The wastes caused by the operation of the ships at sea and the oil and derivatives used on the ship or other harmful substances that are released into the sea from the ships can cause marine pollution seriously. The provisions to be applied to marine pollution are determined according to the pollutant causing marine pollution and the type of the ship. In our law, liability arising from pollution caused by pollutants other than petroleum and its derivatives is basically regulated in the Law No. 5312 "The Principles of Emergency Intervention and Compensation for Damages in Pollution of the Marine Environment with Petroleum and Other Harmful Substances". Türkiye is also a party to two international conventions on pollution caused by oil and its derivatives. These contracts are the "The International Convention on Civil Liability for Oil Pollution Damage" and "The International Convention on Civil Liability for Bunker Oil Pollution Damage". On the other hand, the Environmental Act is also applied for liability arising from marine pollution in cases that do not fall within the scope of application of the enumerated legislation. The marine pollution can be prevented by virtue of the deterrent effect of the regulations on legal liability arising from the pollution of the sea originating from ships.

**Keywords:** Marine Pollution, Act of 5312, Responsibility of Marine Pollution

## Giriş

Denizlerdeki canlı hayata olumsuz etki eden, insan sağlığı bakımından tehdit oluşturan, denizlerden ekonomik olarak yararlanılmasını kısıtlayan veya engelleyen her türlü kirlenme deniz kirlenmesi kavramı içinde yer almaktadır (Özdemir, 2012)[1]. Deniz kirlenmesinin önlenmesi ve kirlenme sonucunda ortaya çıkan zararların tazmin edilmesi hususunda ülkemiz uluslararası sözleşmelere taraftır. Öte yandan iç hukukumuzda birden fazla düzenleme bulunmaktadır. Sözü geçen uluslararası sözleşmelerin ve iç hukuk düzenlemelerinin uygulama alanları temel olarak denizde kirlenmeye sebep olan maddeye ve kirlenmenin kaynağı olan geminin özelliklerine göre belirlenmiştir. Bu çerçevede gemilerden kaynaklanan petrol kirlenmesi hakkında özel bir hukuki rejimin söz konusu olduğunu söylemek yerinde olur. Denizin petrol kaynaklı kirlenmesine ilişkin taraf olduğumuz temel sözleşme 27.11.1992 tarihli Petrol Kirliliğinden Doğan Zararın Hukukî Sorumluluğu ile İlgili Milletlerarası Sözleşme (CLC 92)'dir[2]. Ayrıca ülkemiz 27.11.1992 tarihli Petrol Kirliliği Zararının Tazmini İçin Bir Uluslararası Fonun Kurulması ile İlgili Milletlerarası Sözleşme[3]'ye de taraftır.

CLC 92 m.1'de tanımlara yer verilmiştir. Hükme göre "gemi", dökme halde petrol taşımak için inşa edilmiş veya bu amaçla tadil edilmiş her türlü gemiyi ve deniz aracını ifade etmektedir. Sözleşme'de kirlenmeye sebep olan "petrol (oil)" ifadesine ilişkin de tanım yapılmıştır. Bu tanım uyarınca petrol, ham petrol, fuel oil, ağır dizel yağı veya yağlama yağı gibi tüm kalıcı hidrokarbon madeni yağları ifade etmektedir ve bu yağların gemide yük olarak taşınması veya geminin yakıt tankında bulunması gerekir (CLC 92 m. 1/5). CLC 92'nin uygulanma kabiliyetine ilişkin düzenleme Türk Ticaret Kanunu'nda yapılmıştır. TTK'nın 5. Kitabının Yedinci Kısmı "Sorumluluğun Sınırlanması ve Petrol Kirliliği Zararının Tazmini" başlığı ile düzenleme getirmektedir. "Petrol kirliliği zararı hakkında özel hükümler" başlıklı 1336. maddenin 1. fıkrasında CLC 92'nin doğrudan uygulanacağı; gerek doğrudan gerekse TTK uyarınca uygulandığı hâllerde mevzuatın CLC 92'de düzenlenen hususlara ilişkin hükümlerinin uygulanmayacağı hüküm altına alınmıştır. Diğer bir anlatımla CLC 92, uygulama alanına giren kirlenme zararları bakımından münhasıran uygulanır. İç hukukumuzda aynı konuda düzenleme getiren bir kanunun uygulanma imkânı söz konusu değildir (Kuyucu Meriç, 2017)[4].

Denizin petrol kaynaklı kirlenmesine ilişkin taraf olduğumuz temel sözleşmelerden bir diğeri 23.3.2001 tarihli Gemi Yakıtlarından Kaynaklanan Petrol Kirliliği Zararının Hukuki Sorumluluğu Hakkında Milletlerarası Sözleşme (International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001 /BUNKER)[5]'dir[6]. Bunker Sözleşmesi'nin

[1] Ünal ÖZDEMİR, Türkiye'de Gemilerden Kaynaklı Deniz Kirliliğinin İncelenmesi, Batman Üniversitesi Uluslararası Katılımlı Bilim ve Kültür Sempozyumu, 18-20 Nisan 2022, Batman-Türkiye, Batman Üniversitesi Yaşam Bilimleri Dergisi, Cilt 1, Sayı 2 (2012), s. 374. Gemi kaynaklı deniz kirlenmesine ilişkin somut örnekler için bkz.: Hacı KARA, 5312 Sayılı Kanuna Göre Deniz Çevresinin Petrol Ve Diğer Zararlı Maddelerle Kirlenmesinde Zararların Tazmini, Yıldırım Beyazıt Üniversitesi Hukuk Fakültesi Dergisi, Yıl 4, Sayı 2019/1, s. 313 vd.

[2] Bu sözleşme 1969 tarihli Petrol Kirliliğinden Doğan Zararın Hukuki Sorumluluğu İle İlgili Uluslararası Sözleşme'nin 1992 Protokolü ile değiştirilmiş hâlidir. Protocol of 1992 to Amend The International Convention on Civil Liability for Oil Pollution Damage, 1969, bkz.: RG, T. 24.7.2001, S. 24472.

[3] International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage. Ayrıca bu Sözleşme, Protocol of 2003 to the International Convention on the Establishment of an In- ternational Fund for Compensation for Oil Pollution Damage, 1992 ile değişikliğe uğramıştır. Metin için bkz.: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/235985/8490.pdf.

[4] Sözleşmenin uygulama alanına ilişkin ayrıntılı açıklamalar için bkz.: Gülfer KUYUCU MERİÇ, Donatanın Petrol Kirliliğinden Doğan Sorumluluğu ve Sınırlandırılması, Filiz Kitabevi, İstanbul, 2017, s. 120 vd.

[5] RG: T. 27.7.2013, S. 28720.

[6] "1996 Tehlikeli ve Zararlı Maddelerin Deniz Yoluyla Taşınmasına İlişkin Zararlardan Sorumluluk ve Tazminata Dair Milletlerarası Sözleşme (HNS)" de deniz kirlenmesine ilişkin önemli bir uluslararası sözleşmedir. Türkiye Sözleşme'ye taraf olma iradesini ortaya koyan ilk ülkelerdendir. Ancak sözleşme uzun yıllar yürürlüğe girememiştir. HNS'nin yürürlüğüne ilişkin bkz.: Ms. Mariam MGELADZE (Submitted By), Martínez Norman A. Gutiérre (Supervisor), A Law To Incorporate The International Convention On Liability And Compensation For Damage In Connection With The Carriage of Hazardous And Noxious Substances By Sea, 2010 Into The Law Of Georgia, IMO International Maritime Law Institute, s. 30 vd.: https://imli.org/wp-content/uploads/2020/12/LDP-HNS-Convention-Mariam-Mgeladze.pdf. 1996 HNS (Sözleşme 2010 tarihli Protokol ile değişikliğe uğramıştır ve Protokol ile değişik hâliyle "2010 HNS" olarak anılmaktadır.) bakımından dikkat çeken husus Avrupa Birliği tarafından da üye devletlere sözleşmeye taraf olunması yönünde tavsiyede bulunulmasına rağmen yeterli katılımın sağlanamamasıdır. AB'nin bu yöndeki düzenlemelerine örnek olarak bkz.: Council Decision (EU) 2017/769 of 25 April 2017 on the ratification and accession by Member States, in the interest of the European Union, to the Protocol of 2010 to the International Convention on

tanımlara ilişkin 1. maddesinin 1. fıkrasına göre Sözleşme, tipine bakılmaksızın her türlü gemi ve deniz aracı hakkında uygulanır. Sözleşme, geminin veya deniz aracının işletilmesi veya sevk edilmesi için kullanılan veya kullanılması amaçlanan yağlama yağı da dâhil olmak üzere her türlü hidrokarbon madeni yağ veya bu yağın kalıntısından kaynaklanan deniz kirlenmesi hakkında uygulanır (BUNKER m. 1/5). Türkiye, Bunker Sözleşmesi'ne 2013 yılında taraf olmuştur[7]. CLC 92 hakkında geçerli olan TTK m. 1336/1, Sözleşme'ye taraf olmamızdan önce düzenlenen bir hükümdür. Buna karşılık, Bunker Sözleşmesi'nin de, CLC 92 gibi, uygulama alanına giren hallerde münhasıran uygulanacağı hususunda şüphe bulunmamaktadır.

Yukarıda sözü geçen iki uluslararası sözleşmenin münhasır uygulanma kabiliyetleri sebebiyle iç hukukumuzun deniz kirlenmesine ilişkin düzenlemelerinin uygulama alanı oldukça daralmıştır. Petrol dışındaki diğer zararlı maddelerden kaynaklanan deniz kirlenmesi ise 5312 sayılı "Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanun" ("5312 Sayılı Deniz Kirlenmesi Kanunu / DKK")'a tâbidir. Çalışmamızın konusunu sınırlandırmak amacıyla, 5312 Sayılı Deniz Kirlenmesi Kanunu kapsamında petrol dışındaki zararlı maddelerle gemi kaynaklı deniz kirlenmesinin önlenmesine ve kirlenmeden kaynaklanan zararların tazminine ilişkin esaslar incelenecektir.

## Materyal ve Metot

Çalışmada gemilerden kaynaklanan deniz kirlenmesi hukuki bakış açısı ile incelendiğinden ve petrol dışındaki zararlı maddelerden kirlenmenin incelenmesi hedeflendiğinden iç hukuk düzenlemelerimiz esas alınmıştır. Bu konu hakkındaki iç hukuk düzenlememiz temel olarak 5312 sayılı "Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanun" dur. Zira bu kanunun özel niteliği Çevre Kanunu'nun uygulama alanını önemli ölçüde daraltmıştır[8]. İnceleme metodu olarak 5312 sayılı Kanun kapsamında deniz kirlenmesinin önlenmesine ilişkin esaslar belirlenmiştir. Kanun'un uygulama alanı gemi, kirleten madde, ortaya çıkan zarar, kirlenmeden sorumlu tutulan kişi esas alınarak incelenmiştir. 5312 Sayılı Kanun'un uygulama alanının belirlenmesine ilişkin hükümlerindeki isabetsizlikler tespit edilmiş ve eleştirilmiştir. Çelişkili hükümlerin ne yönde yorumlanmasının uygun olacağı genel hukuk ilkeleri ve hükümlerin konuluş amacı dikkate alınarak değerlendirilmiştir.

## Bulgular ve Tartışma

Deniz kirlenmesine ilişkin ülkemizin taraf olduğu uluslararası sözleşmelerin münhasır uygulanma kabiliyeti karşısında 5312 Sayılı Deniz Kirlenmesi Kanunu'nun uygulama alanı Kanun'un düzenlenmesi sırasındaki amacına hizmet edememektedir. Zira gemi kaynaklı deniz kirlenmesi petrol ve yakıt kaynaklı kısmı bu uluslararası sözleşmelerin uygulama alanında kalmaktadır. Buna karşılık 5312 sayılı Kanun'un uygulama alanında petrol ve yakıt dışındaki tüm kirletici maddeler ile tüm tür gemiler girmektedir. Öte yandan Kanun'un özel kanun niteliği itibariyle Çevre Kanunu'nun da uygulanma kabiliyeti bulunmamaktadır. Bu derece geniş bir uygulama alanına sahip olmasına rağmen Deniz Kirlenmesi Kanunu'nun kanun yapma tekniğine uygun şekilde kaleme alınmadığı ve önemli nitelikte çelişkili düzenlemeler içerdiği belirlenmektedir. Bu çelişkili hükümlerden kuşkusuz ki en önemli olanı Kanun'un uygulanacağı gemilerin belirlenmesine ilişkin hükümlerdir. Söz konusu hükümlerin Kanun'un düzenlenme amacına uygun şekilde yorumlanması gerekmektedir. Kanun'un amacı olabildiğince geniş bir uygulama alanına sahip olmaktır ve hükümlerin mümkün olduğunca tonaj sınırı aranmaksızın uygulanması sağlanmalıdır. Yine uygulama alanını belirleyen ve kirleten madde, zarar ile zarar sorumlusuna ilişkin olan hükümlerin tümünün en geniş şekilde uygulanması denizin gemi kaynaklı kirlenmesinin önlenmesinde etkili olacaktır.

---

Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, with the exception of the aspects related to judicial cooperation in civil matters; Council Decision (EU) 2017/770 of 25 April 2017 on the ratification and accession by Member States, in the interest of the European Union, to the Protocol of 2010 to the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, with regard to the aspects related to judicial cooperation in civil matters. Düzenlemeler için bkz.: https://eur-lex.europa.eu.
Ayrıca 1996 HNS hakkında bkz.: https://www.imo.org/en/MediaCentre/HotTopics/Pages/HNS-2010.aspx: Çevrimiçi, erişim tarihi: 27.09.2023. İsmail DEMİR, Hukuki Sorumluluk ve Tazminat Esasları Açısından Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, İnönü Üniversitesi Hukuk Fakültesi Dergisi Cilt:2 Sayı:1 Yıl:2011, s. 271-272.

[7] 2013/5110 Sayılı Bakanlar Kurulu Kararı ile sözleşmeye taraf olmamız uygun bulunmuştur. 27.07.2013 Tarih 28720 Sayılı RG'de bu karar yayımlanarak ülkemiz Sözleşme'ye taraf olmuştur.

[8] Kanunların uygulama alanına ilişkin bkz.: KARA, 5312 Sayılı Kanuna Göre Zararların Tazmini, s. 322 vd.

### *5312 Sayılı Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanun ve İlgili Mevzuata Genel Bakış*

5312 Sayılı Deniz Kirlenmesi Kanunu, *"deniz emniyetinin sağlanması ve deniz kirliliğinin önlenmesi konusundaki uluslararası hukuk ve iç hukuktan doğan hak ve yükümlülükler göz önünde bulundurulmak suretiyle, acil durumlarda gemilerden ve kıyı tesislerindeki faaliyetlerden kaynaklanan kirlenme tehlikesini ortadan kaldırmak veya kirlenmeyi azaltmak, sınırlamak ve gidermek üzere uygulanacak müdahale ve hazırlıklı olma esaslarını, olay sonucu ortaya çıkan zararların tespit ve tazmin esaslarını, uluslararası yükümlülüklerin yerine getirilmesi esaslarını, Kanun kapsamına giren kişilerle kurum, kuruluş, gemi ve tesislerin Kanunda belirtilen ilgililerinin yetki, görev ve sorumluluklarını belirlemek"* amacıyla düzenlenmiştir (DKK m. 1). Kanun'da hem deniz kirliliğinin önlenmesi, kirliliğe acil müdahale ve hazırlıklı olunması esasları hem de denizin kirlenmesi halinde kirlenmeden kaynaklanan zararlardan sorumluluk ile zararın tazminine ilişkin esaslar yer almaktadır (Demir, 2011)[9].

Kanun kapsamında belli hususların yönetmelik ile düzenlenmesi hüküm altına alınmıştır. Örneğin, Kanun'un 5. maddesinin 3. fıkrası uyarınca gemilerin yapacağı bildirimler, aynı maddenin 6. fıkrası uyarınca seyir, can, mal ve çevre emniyetini sağlamak amacıyla alınan tedbirlerin denetimine ilişkin usûl ve esaslar ile son fıkrası uyarınca kıyı tesislerinin, muhtemel kirliliğe müdahale etmek üzere bulundurmak zorunda oldukları personel, malzeme ve ekipmanlar ile ilgili usûl ve esaslar yönetmelikle belirlenecek hususlardandır. 5312 Sayılı DKK'ye dayanılarak "Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale Ve Zararların Tazmini Esaslarına Dair Kanunun Uygulama Yönetmeliği[10]" ile "Deniz Çevresinin Petrol Ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanun Kapsamında Mal Ve Hizmet Alımına İlişkin Yönetmelik[11]" yürürlüğe konulmuştur. Ayrıca Deniz Çevresinin Petrol ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale ve Zararların Tazmini Esaslarına Dair Kanun'a ilişkin Uygulama Yönetmeliği'nin icrası kapsamında deniz çevresinin petrol ve diğer zararlı maddelerle kirliliğine müdahale edebilecek şirket/kurum/kuruluşların asgari özelliklerinin belirlenmesi, yetki belgesi verilmesi, görevlendirilmesi ve buna ilişkin usûl ve esaslar ile kıyı tesislerinin sorumluluklarını düzenlemek üzere "2009/4 nolu Deniz Çevresinin Petrol Ve Diğer Zararlı Maddelerle Kirlenmesinde Acil Durumlarda Müdahale Görevi Verilebilecek Şirket/Kurum/Kuruluşların Seçimine Ve Yetki Belgesi Bulunan Şirket/Kurum/Kuruluşlar İle Kıyı Tesislerinin Çalışma Usullerine İlişkin Tebliğ[12]" çıkarılmıştır.

### *5312 Sayılı Deniz Kirlenmesi Kanunu'nun Uygulama Alanı*

#### *A. Gemiler Bakımından*

5312 Sayılı Deniz Kirlenmesi Kanunu'nun "Kapsam" başlıklı 2. maddesine göre Kanun, *"uygulama alanlarında bulunan veya herhangi bir nedenle uygulama alanlarına girmek isteyen, beşyüz groston ve daha büyük petrol ve diğer zararlı maddeleri taşıyan gemiler ile petrol ve diğer zararlı maddelerle kirlenmeye neden olabilecek faaliyetleri icra eden kıyı tesisleri"* hakkında uygulanır. Görüldüğü üzere Kanun, gemiler bakımından 500 groston sınırını belirlemiştir (Kuyucu Meriç. 2017)[13]. Bu sınırın belirlenmesinin sebebi Kanun'un gerekçesinde de belirtilmemiştir (Demir, 2011)[14]. Öte yandan hükümde geminin türü bakımından bir esas öngörülmediği gibi Kanun'da gemi tanımına da yer verilmemiştir[15].

DKK m. 2 f.2'ye göre *"savaş gemileri ve yardımcı savaş gemileri ile herhangi bir devlete ait veya devlet tarafından*

[9] Zararlardan sorumluluk ve tazmin esaslarının aynı kanunda düzenlenmesinin isabetsiz olduğu yönünde haklı eleştiri için bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 239.

[10] 21.10.2006 Tarihli, 26326 Sayılı RG.

[11] 06.04.2006 Tarihli, 26150 Saylı RG.

[12] 30.10.2009 Tarihli, 27391 Sayılı RG.

[13] Öğretide bu ifadenin gemi değil yüke ilişkin olduğuna dair bir izlenim oluşturduğu; oysa 500 groston ölçüsünün gemiye ilişkin olduğu vurgulanmaktadır.: KUYUCU MERİÇ, Petrol Kirliliğinden Doğan Sorumluluk, s. 85. Yükün değil geminin 500 grostondan fazla olmasının arandığı yönünde bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 275. Hükmün kaleme alınışının başarısız olduğu yönünde bkz.: KUYUCU MERİÇ, Petrol Kirliliğinden Doğan Sorumluluk, s. 85.

[14] 500 groston yerine MARPOL 73/78'e paralel şekilde 150 groston sınırının aranmasının uygun olacağına dair Komisyon görüşü ve süreç hakkında bkz.: TBMM Tutanak Müdürlüğü, Çevre Komisyonu, Birinci Oturum, Giriş: 10.30, T. 3.11.2004, s.3. Bu konuda ayrıca bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 276.

[15] Bu durumun da Kanun'un düzenlenmesindeki özensizlikten kaynaklandığı; Kanun'un kamu hukuku karakteri dikkate alınırsa Denizde Can ve Mal Koruma Hakkında Kanun'daki gemi tanımının esas alınabileceği yönünde bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 275. Kanun uyarınca "gemi" hakkında ayrıca bkz. KARA, 5312 Sayılı Kanuna Göre Zararların Tazmini, s. 325 vd.

*işletilen ve ticarî faaliyetler dışında kullanılan gemiler Kanun kapsamı dışındadır."* Dolayısıyla bu tür gemilerin sebep olduğu deniz kirlenmesi hakkında Kanun'un uygulanma imkânı bulunmamaktadır.

5312 Sayılı Deniz Kirlenmesi Kanunu'nun gemiler bakımından uygulama alanını belirleyen diğer bir hükmü 23. maddesidir. Öncelikle bu hükmün bulunduğu yerin kanun yapma tekniği bakımından isabetli olmadığı belirtilmelidir. Zira kanunun aynı ölçüt bakımından uygulama alanını belirleyen esaslarının aynı hükümde düzenlenmesi uygun olur (Demir, 2011)[16]. Uygulama alanına ilişkin düzenleme getiren maddenin kenar başlığının "Gemi yakıtlarından ve yüklerden kaynaklanan kirlilik" olması da ayrıca eleştirilmelidir.

Hüküm incelendiğinde isabetsizliğin sistematik ile sınırlı kalmadığı görülmektedir. Hüküm şu şekildedir: *"Bir olayda, bu Kanuna tâbi olan veya olmayan bir geminin yakıt olarak taşıdığı petrol veya türevlerinden veya bu Kanuna tâbi olmayan geminin taşıdığı diğer zararlı maddelerden/yüklerden meydana gelen kirliliğe veya kirlilik tehlikesine müdahale ve zararların tespit ve tazmininde, bu Kanunun 5 inci maddesinin üçüncü fıkrası ile 8 inci ve 9 uncu maddeleri dışındaki hükümleri uygulanır. Türkiye'nin taraf olduğu uluslararası sözleşme hükümleri saklıdır."*

Öncelikle DKK, gemilerden kaynaklanan kirlenme açısından kirletici maddenin petrol veya diğer bir zararlı madde olmasını ararken bu maddenin gemide yük veya yakıt olarak bulunması bakımından bir ayrıma gitmemektedir (Demir, 2011)[17]. Ayrıca *"Kanun'a tabi olan ve olmayan"* ifadesine de değinilmelidir. Hüküm, Kanun'a tabi olmayan gemilere belli istisnalar dışında Kanun'un hükümlerinin uygulanmasını öngörmektedir. Bu durumda 2. maddede belirlenen uygulama alanının anlamı tartışmalı hâle gelmektedir (Kara, 2019)[18]. Öte yandan Kanun kapsamına giren gemilerin yakıt olarak taşıdığı petrol veya türevlerinden kaynaklanan zararlar bakımından Kanun'un belli hükümlerinin uygulanma kabiliyetinin bulunmaması da isabetli değildir. Zira bu hükümler seyir, can, çevre ve mal emniyetine ilişkin standartların mevcudiyeti ve bildirimlere (m. 5/3), mali sorumluluk garantilerine (m.8) ve mali sorumluluk garantilerinin bildirimine (m. 9) ilişkindir ve uygulanmamalarının haklı bir gerekçesi bulunmamaktadır (Demir, 2011)[19]. Kanımızca Kanun'un 23. maddesinin isabetsiz düzenlemesi karşısında ulaşılabilecek en makul sonuç, 500 grostonun altındaki gemilere de diğer zararlı maddelerden kaynaklanan kirlenme bakımından Kanun'un birçok hükmünün uygulanabilecek olduğudur.

*B. Kirleten Madde Bakımından*

DKK m. 3/1-(m) de verilen tanıma göre "petrol", ***"****Denizlerin Gemiler Tarafından Kirletilmesinin Önlenmesine Ait Uluslararası Sözleşmenin (MARPOL 73/78) I inci ekinin I inci eklentisinde listelenen maddeler ile bu liste ile sınırlı olmaksızın ham petrol, akaryakıt, slaç, rafine ürünler ve toprak altında doğal olarak meydana gelen her türlü sıvı hidrokarbon karışımını"* ifade eder[20]. Deniz kirlenmesine sebep olabilecek ve Kanun'un uygulama alanında yer alan *"diğer zararlı maddeler"* e ilişkin tanım DDK m. 3/1-(d)'de yer almaktadır. Buna göre, *"Denizlerin Gemiler Tarafından Kirletilmesinin Önlenmesine Ait Uluslararası Sözleşmenin (MARPOL 73/78) II nci ekinin II nci ve III üncü eklentilerinde listelenmiş maddeler ile bu liste ile sınırlı olmaksızın deniz ortamına karıştığında kirlenme yaratan radyoaktif maddeler hariç her türlü madde"* diğer zararlı maddelerdendir. Verilen tanıma göre, radyoaktif maddeler hariç olmak üzere denizde kirlenmeye sebep olan her türlü madde Kanun'un uygulama alanındaki diğer zararlı maddelerdendir. Uygulamada deniz kirlenmesine en fazla sebep olan maddeler MARPOL 73/78 ekindeki maddeler olduğundan bu maddelerin örnek gösterilmesinin isabetli bir tercih olduğu ifade edilmektedir (Demir, 2011)[21].

DKK kapsamında kirlenmeye sebep olabilecek maddeler üzerinde durulurken tekrar vurgulanması gereken husus şudur ki, ülkemizin taraf olduğu deniz kirlenmesinden kaynaklanan hukuki sorumluluğa ilişkin sözleşmelerin münhasır uygulanma kabiliyeti karşısında sadece bu

[16] Ayrıca bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 277-278.

[17] DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 277.

[18] Bu konuda örnekler için bkz.: KARA, 5312 Sayılı Kanuna Göre Zararların Tazmini, s. 327 vd.

[19] Hükmün ayrıntılı eleştirisi ve değerlendirmesi için bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 276-279. Ayrıca bkz.: KARA, 5312 Sayılı Kanuna Göre Zararların Tazmini, s. 327-328.

[20] Tanımın oldukça geniş bulunduğu ve 1992 HSS'de verilen petrol tanımından dahi ileri gittiği yönünde bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 280.

[21] Ayrıca MARPOL'ün zararlı maddelerden ne anlaşılması gerektiği hususunda uluslararası alanda genel kabul görmüş bir düzenleme olması, Sözleşme'nin gemi kaynaklı deniz kirlenmesinin önlenmesine yönelik en temel ve teknik uluslararası enstrüman olarak kabul görmesinin de kanun koyucunun isabetli bir tercih yaptığını gösterdiği yönünde bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 280. Ayrıca bkz: KUYUCU MERİÇ, Petrol Kirliliğinden Doğan Sorumluluk, s. 90-91.

sözleşmelerin uygulama alanında bulunmayan zararlı maddeler açısından tatbiki mümkündür. CLC 92, bu Sözleşme'de yer alan "petrol" tanımı kapsamındaki maddeler; Bunker Sözleşmesi ise, bu Sözleşme'de yer alan "gemi yakıtı" tanımı kapsamındaki maddelerden kaynaklanan kirlenme hakkında münhasıran uygulama kabiliyetine sahip olduğundan, bu maddeler dışındaki ve DKK kapsamına giren maddeler bakımından ilgili Sözleşmeler'in DKK'nın önünde yer almaları mümkün değildir. Buna karşılık Çevre Kanunu'nun oldukça geniş bir uygulama alanına sahip olduğu belirtilmelidir. İki kanun arasındaki özellik-genellik ilişkisi esas alındığında Deniz Kirlenmesi Kanunu'nun Çevre Kanunu'na göre özel nitelikli olduğu ve her iki kanunun uygulama alanında gözüken olaylarda DKK'nın uygulanması gerektiği sonucuna varılmalıdır.

*C. Coğrafi Alan Bakımından*

Deniz Kirlenmesi Kanunu'nun uygulama alanı "Tanımlar" başlıklı 3. maddede düzenlenmiştir. Hükme göre "uygulama alanı", *"Türkiye'nin iç suları, karasuları, kıta sahanlığı ve münhasır ekonomik bölgesinden oluşan deniz yetki alanlarını ve bu Kanunda öngörülen acil durumlarda, bu durumlara müdahale ve zararların tazmini amaçlarıyla sınırlı kalmak kaydıyla, Müsteşarlığın, Bakanlık, Dışişleri Bakanlığı ve ilgili diğer kamu kurum ve kuruluşlarının görüşlerini alarak vereceği karara bağlı olarak karasularının ötesindeki açık deniz alanlarını kapsar. (DKK m.3/1- (p)"*

Görüldüğü üzere, Kanun'un uygulama alanında "iç sular", "karasuları", "kıta sahanlığı", "münhasır ekonomik bölge" yer almaktadır. Ayrıca kamu makamının uygun ve gerekli görmesi halinde açık deniz alanları da uygulama alanına dahil edilebilmektedir. Kanun'da, sayılan uygulama alanına dair tanımlara yer verilmediği görülmektedir. Deniz Kamu Hukuku öğretisinde kabul gören tanımların geçerli sayılması uygundur[22]. Buna göre, "iç sular" "karasularının ölçülmeye başlandığı esas hattın kara tarafında kalan deniz alanları (Demir, 2011)[23]"dır. Diğer bir ifadeyle, karasularının iç sınırı ile kara ülkesi arasında kalan deniz kesimi iç suları oluşturmaktadır. "Karasuları", kıyı devletinin kıyıları veya iç sularının dış sınırı ile açık deniz arasında kalan belirli genişlikteki deniz alanı (Demir, 2020)[24], "kıta sahanlığı", kıyı devletinin karasularının ötesinde fakat kıyıya bitişik su altı alanlarının deniz yatağı ve toprak altındaki cansız kaynaklarını araştırma ve işletme konusunda münhasır egemen haklara sahip olduğu deniz alanı (Kuran, 2020; Demir, 2020)[25]"; "münhasır ekonomik bölge", kıyı devletine karasuları esas hattından başlayarak 200 mil genişlikteki deniz alanında kalan su tabakası ile deniz yatağı ve onun toprak altında münhasır ekonomik haklar ve yetkiler tanıyan deniz alanı (Kura, 2020) [26]" ve "açık deniz", hiçbir devletin deniz ülkesine ait olmayan uluslararası deniz alanı (Kuran, 2020; Pazarcı, 2021; Toluner, 1989) [27] olarak anlaşılmalıdır [28]. Kanun'un uygulama alanının oldukça geniş tutulduğu, uygulama alanının daha da genişletilmesine ilişkin yetkinin ise isabetli olarak deniz kirlenmesine ilişkin tedbirleri uygulama sorumluluğuna sahip olan kamu makamlarına verilmiş olduğu belirlenmektedir (Demir, 2011)[29].

*D. Olay Bakımından*

DKK m. 3/1-(j)'ye göre Kanun'un uygulanacağı "olay", *"acil müdahale plânlarının uygulanmasını veya acil müdahaleyi gerektiren çarpışma, kırılma, yangın, patlama veya diğer nedenlerle gemilerden veya kıyı tesislerinden kaynaklanan kirlenme veya zarar ortaya çıkaran veya ortaya çıkma tehlikesi yaratan bir durum"* dur. Denizin kirlenmesine sebep olan veya kirlenmesi tehlikesi ortaya çıkaran çarpışma, kırılma, yangın, patlama Kanun'un uygulanması için yeterlidir. Ayrıca çarpışma, kırılma, yangın, patlama söz konusu olmasa dahi başka sebeplerle gemiden kaynaklanan kirlenme

[22] DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 281.

[23] Bu tanım Birleşmiş Milletler Deniz Hukuku Sözleşmesi m. 8/1'de esas alınan tanımdır. Tanıma göre, karasularının iç sınırı ile kara ülkesi arasında kalan deniz kesimi iç sularıdır.: İsmail DEMİR, Türk Deniz Yetki Alanlarının Belirlenmesinin Hukuki Dayanakları ve İç Hukuk Üzerine Bazı Düşünceler, Adalet Dergisi, 2020/2, Sayı: 65, s. 32. "İç su, genel anlamada denizlerden uzak bölgelerde bulunan göl veya göletler olarak tanımlanmaktadır.": https://sozluk.gov.tr. Çevrimiçi, erişim tarihi: 27.09.2023.

[24] DEMİR, Türk Deniz Yetki Alanları, s. 32. 20.05.1982 tarihli, 2674 sayılı Karasuları Kanunu'nun 1. maddesinin 1. ve 2. fıkralarına göre, "Türk karasuları Türkiye ülkesine dahildir." ve "Türk karasularının genişliği altı deniz milidir."

[25] Selami KURAN, Uluslararası Deniz Hukuku, Beta, İstanbul, 2020, s. 229. Ayrıca bkz.: DEMİR, Türk Deniz Yetki Alanları, s. 34. Coğrafi yönden kara suları, denizin 133 metreye kadar derinleştikten sonra büyük derinliklere ulaştığı keskin yamaç ile kıyı arasındaki alanı ifade etmektedir.: KURAN, Uluslararası Deniz Hukuku, s. 229; DEMİR, Türk Deniz Yetki Alanları, s. 34.

[26] KURAN, Uluslararası Deniz Hukuku, s. 251.

[27] KURAN, Uluslararası Deniz Hukuku, s. 287; Hüseyin PAZARCI, Uluslararası Hukuk Dersleri, Turhan Kitabevi, Ankara, 2021, s.; Sevin TOLUNER, Milletlerarası Hukuk Dersleri, Beta, İstanbul, 1989, s. 290 vd.

[28] Açık denizde gerçekleşen kirlenmeye Türkiye'nin müdahale hakkının Uluslararası Hukuk kuralları çerçevesinde belirlenmesi gerektiği yönünde bkz.: KUYUCU MERİÇ, Petrol Kirliliğinden Doğan Sorumluluk, s. 92.

[29] Bu konuda bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 281.

de uygulama alanında yer almaktadır. Dolayısıyla "gemiden" kaynaklanması şartıyla kirlenmeyi meydana getiren olay ne olursa olsun Kanun'da öngörülen acil durum planlarının uygulanmasını veya acil müdahaleyi gerektiriyorsa hükümlerin tatbiki mümkündür.

Kanun'un uygulanma imkânına sahip olması için gerçekleşmesi gereken olayın sonucunda bir "kirlenme" nin meydana gelmiş olması aranır. "Kirlenme", Kanun'da nitelenen "olay" sonucunda petrol ve diğer zararlı maddelerin:

*"- canlı kaynaklara ve deniz yaşamına zarar verecek*

*- insan sağlığı için tehlike oluşturacak,*

*- balıkçılık ve denizlerin diğer yasal amaçlarla kullanımı da dahil olmak üzere, denizcilik faaliyetlerini engelleyecek,*

*- deniz suyunun niteliğini değiştirme ve ekolojik dengeyi bozma gibi zararlı etkiler yaratacak şekilde deniz çevresine karışması"*

nı ifade etmektedir *(DKK m. 3/1 (h))*.

Görüldüğü üzere, Kanun koyucu denizdeki canlı kaynaklar, insan sağlığı, balıkçılık ve diğer yasal faaliyetler, deniz suyu ve ekolojik denge açısından zararlı etki doğuracak her türlü karışmayı kirlenme olarak nitelemektedir. Bu düzenleme de uygulama alanının oldukça geniş tutulmak istendiğini ortaya koymaktadır.

*E. Zarar Bakımından*

Kanun'un uygulama alanının tespiti açısından en önemli hususlardan bir diğeri, "olay" ın gerçekleşmesi sonucunda ortaya çıkan hangi zararların tazmininin talep edilebileceğidir. Bu husus uygulama alanına ilişkin diğer esaslarda olduğu gibi "Tanımlar" maddesinde düzenlenmiştir.

DDK m. 3/1- (r)'ye göre, Kanun'un 6. maddesinde belirtilenler ile zararın tespitine, tazminine ve uyuşmazlıkların giderilmesine ilişkin masrafların tazmini talep edilebilir[30]. İşaret edilen 6. madde Kanun'un sorumluluğa ilişkin temel hükmüdür. "Zarardan dolayı sorumluluk" başlıklı hükmün 1. fıkrasına göre, *"Bu Kanun kapsamına giren gemi ve kıyı tesislerinin sorumlu tarafları, uygulama alanlarında gemi ve kıyı tesislerinden kaynaklanan olay sonucu ortaya çıkan kirlenmenin veya kirlenme tehlikesinin neden olduğu; temizleme masraflarını, koruyucu önlemlere ilişkin masrafları, canlı kaynaklar ve deniz yaşamına verilen zararları, bozulan çevrenin yeniden oluşturulması, toplanan atıkların taşınması ve bertarafı için yapılacak masrafları, geçim için kullanılan doğal ve canlı kaynaklarda meydana gelen zararları, özel mallardaki zararları, şahısların yaralanması ve ölümünden kaynaklanan zararları, gelir kayıplarını, gelir ve kazanç kapasitelerine verilen zararları ve diğer kamu zararlarını tazmin etmekle müteselsilen sorumludur."* Görüldüğü gibi zarar listesi genel prensibe paralel şekilde oldukça geniş tutulmuştur. Kirlenme veya kirlenme tehlikesinin sebep olması şartıyla,

*"- temizleme masrafları,*

*- koruyucu önlemlere[31] ilişkin masraflar,*

*- canlı kaynaklar ve deniz yaşamına verilen zararlar,*

*- bozulan çevrenin yeniden oluşturulması, toplanan atıkların taşınması ve bertarafı için yapılacak masraflar,*

*- geçim için kullanılan doğal ve canlı kaynaklarda meydana gelen zararlar,*

*- özel mallardaki zararlar,*

*- şahısların yaralanması ve ölümünden kaynaklanan zararlar,*

*- gelir kayıpları, gelir ve kazanç kapasitelerine verilen zararlar,*

*- diğer kamu zararları"*

tazmini talep edilecek zararlardandır.

*F. Sorumlu Tutulacak Kişi Bakımından*

5312 Sayılı DKK gereğince denizde kirlenmeden kaynaklanan zararlardan sorumlu tutulabilecek kişilerin listesi oldukça geniştir. Muhtemel zarar sorumluları 6. maddede "Zarardan dolayı sorumluluk" başlığı altında "sorumlu taraflar" ifadesiyle belirtilmiştir. Bu ifade ile işaret edilmek istenen kişilerin kimler olduğu ise tanımlara ilişkin 3. maddede açıklanmıştır. Buna göre "sorumlu taraf", *"zararın tazmini ve koruyucu önlemlerin karşılanması konusunda yükümlülük atfedilebilecek, beş yüz groston ve daha büyük petrol ve diğer zararlı maddeleri taşıyan gemiler ile kıyı tesislerinin sahipleri, işletenleri, kaptanları, idare edenleri, kiracıları, zilyetleri ve garantörleri"*dir. Bu tanım esas alındığında, gemilerden kaynaklanan kirlenmeden sorumlu

[30] Hükmün kanun yapma tekniğine uygun olmadığına ilişkin değerlendirmeler için bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 283-283.

[31] Koruyucu önlem: Bir olayın meydana gelmesinden sonra ortaya çıkabilecek muhtemel kirlenmeyi önlemek veya sınırlı tutmak amacıyla alınan tedbirler (DKK m. 3/1 (ı)).

tutulabilecek kişilerin "geminin maliki, işleteni, kaptanı, idare edeni, kiracısı, zilyedi, garantörü" olabileceği sonucuna ulaşılmaktadır.

*"Geminin maliki"* nden anlaşılması gereken, gemiyi işletmiyor olsa da mülkiyetine sahip olan kişidir. Geminin donatanı (TTK m. 1061/1) ile donatan olmayan malik bu kapsamdadır. Geminin "işleteni" TTK m. 1061/2 anlamında *"kendisinin olmayan bir gemiyi menfaat sağlamak amacıyla suda kullanan"* kimseye karşılık gelmektedir. Bu bakımdan geminin "malik" inin da gemiyi denizde kullanması halinde "işleten" sıfatıyla, geminin işletilmesini bir başka kişiye bırakması halindeyse bu kişinin "kiracı" sıfatıyla sorumlu tutulabileceği sonucuna varılmalıdır. Geminin "idare edeni" kavramı ile işaret edilmek istenen kişilerin kim veya kimler olabileceği oldukça muğlaktır. Örneğin, geminin teknik ve ticari yönetimini bir gemi yönetimi sözleşmesi çerçevesinde üstlenmiş olan gemi yöneticisi gemiyi donatanın nam ve hesabına idare etmektedir. Zira gemi yöneticisi, donatan ile kurduğu sözleşme çerçevesinde donatana ait geminin veya gemilerin ticari, teknik veya diğer alanlardaki yönetimini tümüyle veya kısmen üstlenen ve bu ediminin karşısında kendisine ücret ödenen gerçek veya tüzel kişidir (Şeker Öğüz, 2013)[32]. Gemi yöneticisi, donatanı temsilen hareket ettiğinden temsil ettiği kişiye yüklenebilecek bir sorumluluğun muhatabı olması temsil hukuku esaslarına göre mümkün değildir [33] . Geminin "zilyedi" ifadesinin karşılığı belirlenirken TMK m. 973/1 esas alınmalıdır. Hükme göre, bir şey üzerinde fiili hâkimiyete sahip olan kimse onun zilyedidir. Şu hâlde gemi üzerinde fiili hâkimiyete sahip olan her kişi deniz kirlenmesinden sorumlu tutulabilir. Bu kişinin geminin maliki ile içinde bulunduğu hukuki ilişkinin bir öneminin olmadığını belirtmek gerekir. Gemiyi haksız şekilde malikin fiili hâkimiyetinden çıkarmış ve kendi hâkimiyetine almış olan kişi de "zilyet" sıfatıyla sorumlu tutulabilecektir. Geminin "garantörleri" geminin işletilmesinden kaynaklanan sorumluluğa ilişkin sigorta teminatı sağlayan kişileri ifade eder. 5684 Sayılı Sigortacılık Kanunu[34] m. 15/1 gereğince *"Türkiye'de yerleşik kişiler, Türkiye'deki sigortalanabilir menfaatlerini, Türkiye'de faaliyette bulunan sigorta şirketlerine ve Türkiye'de yaptırmak zorundadır."* Hükmün ikinci fıkrasında yurt dışında kurulabilecek sigorta sözleşmelerine yer verilmiştir. Gemilerin işletilmesinden doğan sorumluluğun teminat altına alındığı sigortalar yurt dışında yapılabilecek sigortalardır. Bu sebeple geminin "garantörü" olarak Türkiye'de kurulmuş bir sigorta şirketi ile karşılaşılabileceği gibi yurt dışında kurulu sorumluluk teminatı sağlayan bir şirket veya başka bir tüzel kişiliğin söz konusu olması da mümkündür.

## Sonuç

Denizin petrol dışındaki zararlı maddeler ile kirlenmesinden kaynaklanan hukuki sorumluluk 5312 Sayılı Deniz Kirlenmesi Kanunu'na tâbidir. Kanun'un düzenlenme amacı hem deniz kirlenmesine acil müdahalenin sağlanması hem de meydana gelen kirlenme zararından kaynaklanan sorumluluk rejiminin oluşturulmasıdır. Bununla birlikte Kanun'un çelişkili bazı hükümler içerdiği ve sistematiğinin de kanun yapma tekniği açısından isabetli olmayan yönlerinin bulunduğu tespit edilmektedir. Öncelikle gemiler bakımından uygulama alanına ilişkin birçok belirsizlik barındırmaktadır. *"...bu Kanuna tâbi olan veya olmayan bir geminin", "bu Kanuna tâbi olmayan geminin"* gibi ifadeler bir yasal düzenlemenin uygulama alanının belirlenmesinde önemli sakıncalar doğuracak muğlak ifadelerdir. Kanun'un uygulama alanının bu tür muğlaklıklara yer vermeyecek şekilde açık ve anlaşılır olması gerekir. Kirleten madde bakımından

[32] Zehra ŞEKER ÖĞÜZ, Gemi Yönetimi Sözleşmesi, Filiz Kitabevi, İstanbul, 2013, s. 7-8. Ayrıca bkz.: Aslıhan SEVİNÇ KUYUCU, BIMCO'nun Gemi Yönetimi Sözleşmesine İlişkin 2009 Değişiklikleri, İstanbul Üniversitesi Hukuk Fakültesi Mecmuası, C. LXXI, S. 2, 2013, s. 361 vd. Sorumlu kişiler listesi dikkate alındığında kanun koyucunun deniz kirlenmesinden sorumlu tutulabilecek herhangi bir kimseyi tespit etme iradesini ortaya koyduğu söylenebilir. Esasen gemi yöneticisini işlemlerini donatanı temsilen yapmaktadır ve geminin işletilmesinden kaynaklanan zararlardan yöneticinin sorumlu tutulamayacağı hususunda şüphe bulunmamaktadır. Gemi yöneticisinin donatanı temsili hakkında bkz.: ŞEKER ÖĞÜZ, Gemi Yönetimi, s. 145-146. Bu noktada belirtilmelidir ki, Kanun kirlenmenin tazminine ilişkin etkili bir sistem oluşturma gayretindeyse de sorumluluk hukuku bakımından isabetsiz düzenlemelere yer vermiştir. Özellikle kaptanın kirlenmeden sorumlu tutulacak kişiler arasında olması, yine kaptanın donatanı temsilen hareket ettiği dikkate alındığında, aşırı bir düzenleme olarak karşımıza çıkmaktadır. Kanun'un sorumlu kişiler listesinin ve müteselsil sorumluluk esasının deniz kirlenmesinden sorumluluğa ilişkin uluslararası sözleşmelerin benimsediği esaslara da aykırı olduğu, muğlak olduğu ve özellikle kaptanın kirlenmeden sorumlu tutulmasının isabetsizliğine ilişkin ayrıntılı açıklamalar için bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 289 vd. Gemi yöneticisinin "idare eden" kişi olduğu yönünde bkz.: KARA, 5312 Sayılı Kanuna Göre Zararların Tazmini, s. 331 vd. Kanun'un ulularararası sözleşmelerde benimsenen "sorumluluğun tek bir kişiye yöneltilmesi ilkesi"ni benimsemediği yönünde bkz.: DEMİR, Zararların Tazmini Esaslarına Dair Kanunun Değerlendirilmesi, s. 290-291; KUYUCU MERİÇ, Petrol Kirliliğinden Doğan Sorumluluk, s. 95.

[33] "İdare edenleri" ifadesinin gemi yöneticisine işaret ettiği yönünde bkz.: KARA, 5312 Sayılı Kanuna Göre Zararların Tazmini, s. 331-332.

[34] 14.06.2007 Tarihli, 26552 Sayılı RG.

değerlendirildiğinde ülkemizin taraf olduğu deniz kirlenmesine ilişkin uluslararası sözleşmelerin münhasır uygulanma kabiliyeti gereği Kanun'un uygulama alanının oldukça daraldığı, Çevre Kanunu karşısında da öncelikli uygulanma imkânına sahip olduğu belirlenmektedir. Kanun, deniz kirlenmesine sebep olan madde ve kirlenme sonucunda ortaya çıkan zarar türleri bakımından uygulama alanını oldukça geniş tutmuştur. Bu oldukça isabetli bir yaklaşımdır. Zira deniz kirlenmesine sebep olan maddeler çeşitlilik gösterirken meydana gelen zarar türleri de aynı şekilde çeşitlidir. Bu düzenleme sayesinde denizin kirletilmesinin caydırılması açısından etkili bir sistem kurulmuş olmaktadır. Deniz kirlenmesinden kaynaklanan zarardan sorumlu tutulabilecek kişiler de geniş bir liste olarak verilmiştir. Esasen Kanun'un sorumlu kişi açısından kendine özgü ancak sorumluluk hukuku esaslarıyla bağdaşmayan, muğlak bir düzenleme yaptığını söylemek yerindedir. "Kirleten öder." yaklaşımı belirlenerek kirlenme bakımından sorumluluk atfedilebilecek tüm kişiler ile bu kişilerin sorumluluklarına karşı teminat sağlayan kişiler söz konusu listede yer almaktadır. Her ne kadar kaleme alınışı itibariyle isabetsiz düzenlemelere yer vermişse de Deniz Kirlenmesi Kanunu'nun uygulamada etkili bir tazminat rejimi oluşturduğu tespit edilmektedir.

**Etik Standartlar ile Uyumluluk**

**Çıkar çatışması:** Yazarlar bu yazı için gerçek, potansiyel veya algılanan çıkar çatışması olmadığını beyan etmişlerdir.

**Etik izin:** Çalışma etik izin gerektirmemektedir.

**Veri erişilebilirliği:** Veriler talep üzerine sağlanacaktır.

**Finansal destek:** -

**Teşekkür:** -

**Açıklama:** -

## Kaynaklar

**Demir, İ. (2011).** Hukuki sorumluluk ve tazminat esasları açısından deniz çevresinin petrol ve diğer zararlı maddelerle kirlenmesinde acil durumlarda müdahale ve zararların tazmini esaslarına dair kanunun değerlendirilmesi, *İnönü Üniversitesi Hukuk Fakültesi Dergisi,* 2(1), 239-325.

**Demir, İ. (2020).** Türk deniz yetki alanlarının belirlenmesinin hukuki dayanakları ve iç hukuk üzerine bazı düşünceler, *Adalet Dergisi*, 65, 27-50.

**Kara, H. (2019).** 5312 sayılı kanuna göre deniz çevresinin petrol ve diğer zararlı maddelerle kirlenmesinde zararların tazmini, *Yıldırım Beyazıt Üniversitesi Hukuk Fakültesi Dergisi*, 4(1), 311-357. https://doi.org/10.33432/ybuhukuk.537917

**Kuran, S. (2020).** Uluslararası Deniz Hukuku, Beta. ISBN: 978-6052-571-8

**Kuyucu Meriç, G. (2017).** Donatanın Petrol Kirliliğinden Doğan Sorumluluğu ve Sınırlandırılması, Filiz Kitabevi, 375 p. ISBN: 978-975-368-446-0

**Mgeladze, Ms. M. (Submitted By), Norman A. M. G. (Supervisor), (2020).** A Law To Incorporate The International Convention On Liability And Compensation For Damage In Connection With The Carriage of Hazardous And Noxious Substances By Sea, 2010 Into The Law Of Georgia, IMO International Maritime Law Institute: https://imli.org/wp-content/uploads/2020/12/LDP-HNS-Convention-Mariam-Mgeladze.pdf (accessed 27.09.2023).

**Özdemir, Ü. (2012).** Türkiye'de Gemilerden Kaynaklı Deniz Kirliliğinin İncelenmesi, *Batman Üniversitesi Yaşam Bilimleri Dergisi*, 1(2), 373-384.

**Pazarcı, H. (2021).** Uluslararası Hukuk Dersleri, Turhan Kitabevi, 289 p. ISBN: 978-975-742-506-9

**Sevinç Kuyucu, A. (2013).** BIMCO'nun Gemi Yönetimi Sözleşmesine İlişkin 2009 Değişiklikleri, *İstanbul Üniversitesi Hukuk Fakültesi Mecmuası*, 71(2), 361-382.

**Şeker Öğüz, Z. (2013).** Gemi Yönetimi Sözleşmesi, Filiz Kitabevi, 266 p. ISBN 978-975-368-362-3

**Toluner, S. (1989).** Milletlerarası Hukuk Dersleri, Beta, 454 p. ISBN 975-486-066-1

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/235985/8490.pdf (accessed 27.09.2023).

https://www.imo.org/en/MediaCentre/HotTopics/Pages/HNS-2010.aspx (accessed 27.09.2023).

https://sozluk.gov.tr (accessed 27.09.2023).

AQUATIC RESEARCH

E-ISSN 2618-6365

Aquatic Research 7(1), 39-50 (2024) • https://doi.org/10.3153/AR24005 *Research Article*

# Investigation of seasonal changes in Annelida fauna and some physicochemical parameters of Riva stream (Istanbul)

**Nilay DÖKÜMCÜ[1], Serap KOŞAL ŞAHİN[2], Menekşe TAŞ DİVRİK[3], Serpil ODABAŞI[4]**

**Cite this article as:**
Dökümcü, N. Koşal Şahin, S., Taş Divrik, M., Odabaşı, S. (2024). Investigate seasonal changes in Annelida fauna and some physicochemical parameters of Riva stream (Istanbul). *Aquatic Research*, 7(1), 39-50. https://doi.org/10.3153/AR24004

[1] Istanbul University Institute of Sciences, Istanbul, Türkiye

[2] Istanbul University Faculty of Aquatic Sciences, Fatih, Istanbul, Türkiye

[3] Sivas Cumhuriyet University, Şarkışla Aşık Veysel Vocational School, Şarkışla, Sivas, Türkiye

[4] Çanakkale Onsekiz Mart University, Marine Science and Technology Faculty, Çanakkale, Türkiye

**ORCID IDs of the author(s):**
N.D. 0000-0003-4326-0753
S.K.Ş. 0000-0001-9256-218X
M.T.D. 0000-0002-4828-2575
S.O. 0000-0003-0709-1534

**Submitted:** 07.11.2023
**Revision requested:** 24.11.2023
**Last revision received:** 28.11.2023
**Accepted:** 29.11.2023
**Published online:** 03.01.2024

**Correspondence:**
Nilay DÖKÜMCÜ
**E-mail:** nilaydokumcu@gmail.com



Available online at
http://aquatres.scientificwebjournals.com

## ABSTRACT

Annelids were collected seasonally at Riva Stream from March 2018 to January 2019. In this study, 1241 individuals (28 taxa; 4 families) of Annelida were identified. Various physicochemical parameter values [depth, width, flow rate, water temperature, dissolved oxygen, pH, electrical conductivity, salinity, TP, o-$PO_4$, $NH_4$-N, $NO_2$-N, $NO_3$-N, TSS] were measured seasonally. The results of the analyses were evaluated according to TSWQR (2021). NPI water index values of the stations were also calculated in the study. Accordingly, it was found that the water quality of Riva and Değirmendere was more polluted than other stations. Bray Curtis similarity analysis was also evaluated regarding physicochemical parameters and taxa. Stations 2 and 3 were the most similar in terms of physicochemical parameters. In terms of taxa, stations 3 and 4 were found to be the most similar stations. According to CCA analysis, *U. uncinata* and *L. hoffmeisteri* appeared closely related to salinity, while *E. tetraedra, H. naidina, H. stagnalis, P. deserticola* and *Nais* sp. were shown closely related to width.

**Keywords:** Oligochaeta, Annelida, NPI, Bray-Curtis, Aquatic ecology, Freshwater

## Introduction

A stream is a continuous body of surface water flowing within the bed and banks of a channel. Depending on its location or certain characteristics, various local or regional names may refer to a stream. Long, large streams are usually called rivers, while smaller, less voluminous, intermittent streams are known as brooks or creeks (Langbein & Iseri, 1995).

Benthic macroinvertebrates are widespread all over the world. They can be found in large rivers, small creeks, ponds, wetlands, and lakes and live on all bottom types, such as sand or rocks. Most benthic macroinvertebrates are present throughout the year; however, they are most easily found in summer. Many species burrow deep in the sediment during the colder months or remain inactive on rock surfaces (IIHR, 2023).

Benthic macroinvertebrates in the river ecosystem are distributed along the river under varying physical and chemical conditions. At the same time, since these organisms are the organisms that are most affected by environmental changes in the river and best reflect the structure of the ecosystem in which they are located, they are the most widely used in biomonitoring studies (Bo et al., 2017; Akay et al., 2018). They are large enough to be seen with the naked eye and are abundant in freshwater. They can be easily collected using a sieve with a pore diameter of 500 μm and examined in the field with a magnifying glass (Fındık, 2013).

The phylum Annelida is divided into three orders: Polychaeta (marine), Oligochaeta (terrestrial and freshwater) and Hirudinea (terrestrial, marine and freshwater leeches) (Wetzel et al., 2009).

The aquatic oligochaetes are the most important macroinvertebrates, adapted to every type of water, such as saltwater, brackish water, and freshwater, including small streams, large rivers, marshes, ponds, lakes, springs, and groundwater. They are found in algae, aquatic vegetation, floating rotting material, and bottom mud (Wetzel et al., 2000). They are an important food source for some invertebrates and fishes. They can be of importance in water management because of their potentially high densities (Brinkhurst & Jamieson, 1971), their wide distribution, and their indicator value (Milbrink, 1973; Chapman et al., 1982; Särkkä, 1994). Leeches live in various extreme environments, including extreme temperatures, humidity, salinity, pressure, pollution, and light (Phillips et al., 2020). Members of the aquatic Hirudinea are tolerant of pollution or habitat disturbance (Demirsoy, 2005).

Riva Stream is a freshwater basin with a length of 70 km located on the Anatolian side of Istanbul. It connects to Ömerli Dam Lake, which provides 43% (approximately 395 million $m^3$ per year) of the drinking water requirement of Istanbul (Anonymous, 2014).

This study aimed to determine the Annelida fauna of Riva Stream and investigate the seasonal changes of some physicochemical parameters. The study is important as the first record of this group in the region.

## Materials and Methods

### *The Study Area*

The Riva Basin has a catchment area of approximately 859 km² (Selçuk & Ongan, 1991; Tarkan, 2007). The stream starts from the village of Tepecik in Gebze and flows into the Black Sea from the town of Riva in Beykoz. Its length between Ömerli Dam Lake and the Black Sea is 32.2 km, and its average slope is 0.06 percent. The area is between 41º14'-41º02' north latitude and 29º08'-29º22' east longitude (Pamukçu, 2011).

Riva Stream, also known as "Çayağzı Stream", lies within the provincial borders of Istanbul and Kocaeli. There are 15 villages in total in Beykoz, Sancaktepe, Çekmeköy and Şile districts of Istanbul and 6 villages in Gebze district of Kocaeli (Akkaya, 2003). The stream passes through the villages of Koçullu, Ömerli, Sırapınar, Hüseyinli, Bozhane, Öğümce, Göllü and Paşamandıra and reaches Çayağzı. The section of the stream after the Ömerli Dam, which meets 48% of Istanbul's drinking water demand, is 75-80% covered with northern forests. The rest of the catchment area consists of agricultural areas and pastures. The people in this part of the basin make a living from agriculture, forestry, animal husbandry and tourism and work as labourers in facilities. Recreation areas, restaurants, and picnic areas are active along the Riva Stream.

A map of the study area and sampling stations is given in Figure 1.

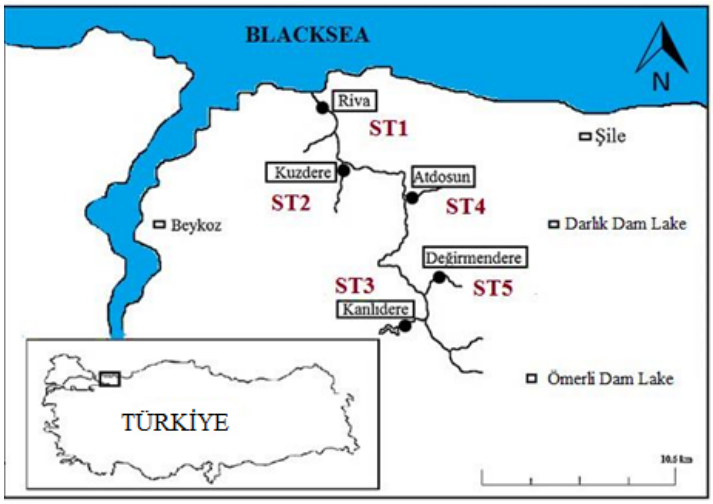
**ST1. Riva:** It is one of the closest points of the Riva Stream to the Black Sea and is located on the main branch of the stream. Heading towards the station's north, one reaches the centre of Riva, the settlement area within the village and the recreational boats. It is quite wide and deep, but the flow velocity is low. Large stones are at the bottom, and the sediment is covered with slime.

**ST2. Kuzdere:** The bottom is covered with large pebbles. Water quality and flow rate vary according to the season. Access to the sampling point is difficult due to private properties and weeds.

**ST3. Kanlıdere:** It is located on the road connecting the old settlement of Reşadiye and Cumhuriyet villages. Except for the spring season, it is a shallow line. The water is clear although the bottom is covered with large and small pebbles.

**ST4. Atdosun:** It is located in Göllü Village. In 2015, it was covered in the national press, and it was observed that there was a line connecting to the tributary where sudden fish deaths occurred. It is narrow and shallow. The bottom is covered with large and small pebbles. In summer, reaching the stream is difficult due to weeds and thorny plants.

**Figure 1.** The study area and sampling stations




Sampling stations and their coordinates are presented in Table 1.

**Table 1.** The sampling stations' coordinates.

| No | Station | Coordinates |
|---|---|---|
| **ST1** | Riva | N41°12'45.88" E29°13'31.22" |
| **ST2** | Kuzdere | N41°10'57.64" E29°13'59.15" |
| **ST3** | Kanlıdere | N41°07'08.30" E29°16'09.80" |
| **ST4** | Atdosun | N41°10'25.00" E29°16'17.60" |
| **ST5** | Değirmendere | N41°07'58.30" E29°16'55.50" |

**ST5. Değirmendere:** The side road opposite the gas station on the right to Ishaklı Village. There are few settlements around it. It is a very deep station. The bottom is covered with loam. *Lemna* sp. covered the water surface in summer.

### *Sampling*

Samples were collected seasonally from the stations from March 2018 to January 2019. A 0.5 mm mesh D-frame hand net was used to collect the samples. Annelid samples were preserved in 70% ethyl alcohol. Annelida samples brought to the laboratory were separated from the sediment, placed in tubes containing 70% alcohol and labelled. After permanent preparation using CMCP-10 (polyvinyl lactophenol), annelids were described by Brinkhurst & Jamieson (1971), Brinkhurst (1975, 1986), Kathman & Brinkhurst (1998), Timm (2009), Wetzel et al. (2000). Since some individuals are deformed or young, they are given as subfamilies. Dominance values were calculated according to Bellan-Santini (1969).

Depth (as cm), width (as cm), flow rate (as m/s), water temperature (as °C), dissolved oxygen (as mg/L), pH, conductivity (as µS/cm), and salinity (as ppm) values were measured by using multiparameter in situ. $NO_3$-N (as mg/L), $NO_2$-N (as µg/L), o-$PO_4$ (as µg/L), TP (as µg/L), and TSS (as g/L) values analysed according to APHA, AWWA, and WPCF (1989). $NH_4$-N (mg/L) values were measured using the SM 4500 $NH_3$ B, F methodology.

### *Water Quality Indice (NPI)*

The nutrient Pollution Index (NPI) is a widely used tool in assessing nutrient pollution in surface water resources based on $NO_3$ and $PO_4$ concentrations (Isiuku & Enyoh, 2020; Larrea-Murrell et al., 2022). The nutrient pollution index calculation formula is given below.

$$NPI = \frac{C_N}{MAC_N} + \frac{C_P}{MAC_P}$$

$C_N$: The levels of $NO_3$-N in water sample (mg/L)

$C_P$: The levels of $PO_4$-P in water sample (mg/L)

$MAC_N$: The maximum limit of $NO_3$-N (mg/L)

$MAC_P$: The maximum limit of $PO_4$-P (mg/L)

$MAC_N$ and $MAC_P$ they are taken from (TSWQR, 2016).

### *Statistical Analysis*

All results obtained were transformed using statistical techniques with LogBase10 in Microsoft Office Excel 2003 and SPSS 9.0 for Windows programs (Krebs, 1999). The similarity of the selected sampling stations in terms of physicochemical parameters and species was compared using Bray-Curtis Cluster Analysis in the BioDi-versity Pro 2.0 programme (McAleece et al., 1997). Canonical Correspondence Analysis was applied to understand the relationship between some physicochemical and biological data (Hammer et al., 2001).

## Results and Discussion

In this study, 1241 individuals total (in $m^2$) belonging to 28 taxa and 4 families of Annelida that 2 taxa belonging to the Lumbricidae family; Lumbricidae, *Eiseniella tetraedra* Savigny, 1826; 1 taxon were identified belonging to Glossiphoniidae family*; Helobdella stagnalis* (Linnaeus, 1758); 3 taxa belonging to the Enchytraeidae family; *Henlea ventriculosa* d'Udekem, 1854; *Henlea perpusilla* Friend, 1911; *Enchytraeus buchholzi* Vejdovský, 1879; 21 taxa belonging to the Naididae family; *Aulodrilus limnobius* Bretscher, 1899; *Homochaeta naidina* Bretscher, 1896; *Limnodrilus claparedeanus* Ratzel, 1868; *Limnodrilus profundicola* Verril, 1871; *Limnodrilus hoffmeisteri* Claparède, 1862; *Limnodrilus udekemianus* Claparède, 1862; *Limnodrilus* sp.; Naidinae; Nais sp.; *Ophidonais serpentina* Müller, 1773; *Pristina* sp.; *Psammoryctides albicola* (Michaelsen, 1901); *Psammoryctides deserticola* (Grimm, 1877); *Potamothrix hammoniensis* (Michaelsen, 1901); *Psammoryctides* sp.; *Rhyacodrilus coccineus* (Vejdovsky, 1875); *Stylaria lacustris* Linnaeus, 1767; *Tubifex tubifex* (Müller, 1774); Tubificinae; *Uncinais uncinata* (Ørsted, 1842); *Vejdovskyella intermedia* Bretscher, 1896 and a subclass, Hirudinea, were identified. The identified taxons are new records for the region.

With 595 individuals (47.95%), the ST5 had the highest number of individuals in all stations. It was followed by ST3 and ST4 with 286 individuals (23.05%) and 226 individuals (18.21%), while ST1 had 85 individuals (6.85%) and ST2 had 49 individuals (3.95%) in total.

According to family dominance (%) in all stations, Naididae was determined to be 91.46%. 21 of 28 taxa belonging to the naidids. The other families were also determined as Lumbricidae 5.40%, Hirudinea 1.53%, Enchytraeidae 1.21%, and Glossiphoniidae 0.40% (Figure 2).

Considering the dominance (%) of seasons according to individual numbers, the winter season had the highest percentage of Annelid at 44.32%. The Autumn season was determined as 31.02%, the summer season was determined as 14.10%, and the spring season was determined as 10.56% (Figure 3).

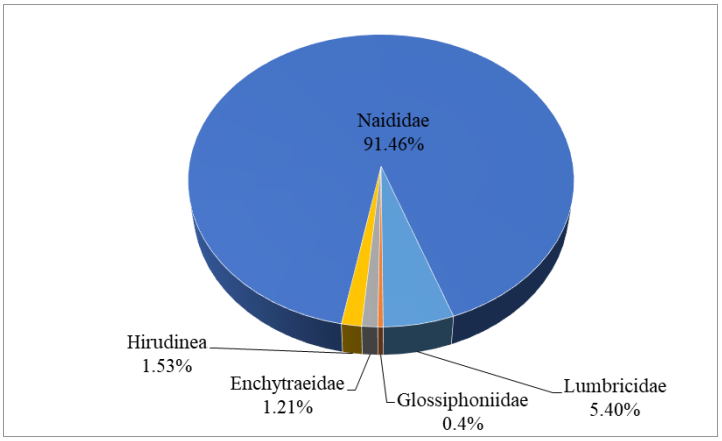



**Figure 2.** The dominance ratio (%) of Annelid families.

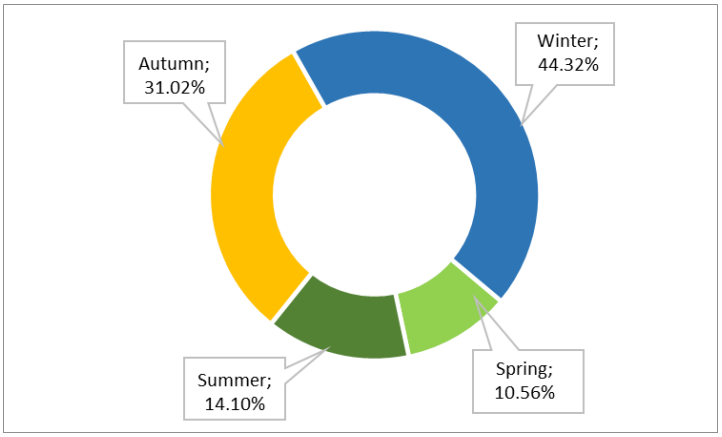



**Figure 3.** The distribution and dominancy rate (%) of taxa in terms of the seasons.

Most Naidid species are cosmopolitan and adapt to different conditions (Brinkhurst & Jamieson, 1971; Wetzel et al., 2000). The most dominant species was *Tubifex tubifex* (293 individuals (23.61%). The Tubificinae subfamily followed up the taxon with 245 individuals (19.74%). Individuals belonging to this subfamily are deformed or juveniles and are therefore given as a subfamily. Therefore, it represents a large group. *L. hoffmeisteri* (77 individuals and 6.20%) was also determined as one of the most dominant species in this study. Together with *T. tubifex* and Tubificane, they were both the most dominant and widely distributed in all stations, despite the difference between the measured physicochemical parameter values. Both *T. tubifex* and *L. hoffmeisteri* are found in organically rich surface water habitats (Brinkhurst & Jamieson, 1971; Brinkhurst, 1975; Wetzel et al., 2000; Hare & Shooner, 1995) *L. hoffmeisteri,* a highly pollution-tolerant

species, is one of the most widely distributed freshwater Oligochaeta worldwide (Arslan & İlhan, 2010).

In order, *P. albicola* (228 individuals, 18.38%) and *O. serpentina* (83 individuals, 6.69%) were determined as the other dominant species. At the same station, *L. udekemianus* was found with 36 individuals, and it is a highly cosmopolitan species that can be distributed even in very different environments (Timm, 1970).

According to Timm (1980), although *A. limnobius, E. tetraedra, L. claparedeanus, Pristina* sp., *R. coccineus*, Lumbricidae, Naidinae, *Nais* sp., *Limnodrilus* sp. are widely distributed and cosmopolitans; except for Lumbricidae, they were found in one or two different stations in this study. Lumbricidae was determined in all stations except the second station.

19 individuals (1.53%) from the Hirudinea subclasses have been examined. While this taxon was found in winter at station 5, it was found in the summer and autumn seasons at station 3. The leeches get oxygen through their skin, and they have a tolerance for pollution or habitat disturbance (Demirsoy, 2005).

The determined species were generally found in previous studies (Arslan, 2006; Demiroğlu & Mısıroğlu, 2010; Koşal Şahin & Yıldız, 2011; Odabaşı et al., 2018; Özbek et al., 2018). *E. tetraedra, E. buchholzi, H. perpusilla, L. hoffmeisteri, L. udekemianus,* Naidinae, *Nais* sp., *O. serpentina P. albicola P. deserticola, S. lacustris, T. tubifex*, Tubificinae species were also reported from Thrace Region (Taş et al., 2012; Aydın & Çamur Elipek, 2019*). H. ventriculosa; H. perpusilla*; *Nais* sp.; *Pristina* sp. and *S. lacustris* were found as single individuals in all stations (0.08%). Total numbers and dominance ratios (%) of taxa in terms of stations are shown in Table 2.

**Table 2.** According to the stations, the individual number of taxa and the dominance (%).

| Familia | Taxon | ST1 | ST2 | ST3 | ST4 | ST5 | T | %D |
|---|---|---|---|---|---|---|---|---|
| Lumbricidae | Lumbricidae | 1 | - | 18 | 22 | 23 | 64 | 5.16 |
| | *Eiseniella tetraedra* Savigny, 1826 | - | 2 | 1 | - | - | 3 | 0.24 |
| Glossiphoniidae | *Helobdella stagnalis* (Linnaeus, 1758) | - | 5 | - | - | - | 5 | 0.40 |
| Enchytraeidae | *Henlea ventriculosa* d'Udekem, 1854 | - | 1 | - | - | - | 1 | 0.08 |
| | *Henlea perpusilla* Friend, 1911 | - | - | 1 | - | - | 1 | 0.08 |
| | *Enchytraeus buchholzi* Vejdovský, 1879 | - | - | 3 | - | 10 | 13 | 1.05 |
| Hirudinea | Hirudinea | - | - | 11 | - | 8 | 19 | 1.53 |
| Naididae | *Aulodrilus limnobius* Bretscher, 1899 | - | - | 6 | - | - | 6 | 0.48 |
| | *Homochaeta naidina* Bretscher, 1896 | - | - | - | 7 | - | 7 | 0.56 |
| | *Limnodrilus claparedeanus* Ratzel, 1868 | - | - | - | 10 | - | 10 | 0.81 |
| | *Limnodrilus profundicola* Verril, 1871 | - | - | - | - | 10 | 10 | 0.81 |
| | *Limnodrilus hoffmeisteri* Claparède, 1862 | 21 | 1 | 23 | 30 | 2 | 77 | 6.20 |
| | *Limnodrilus udekemianus* Claparède, 1862 | - | 3 | 3 | 11 | 19 | 36 | 2.90 |
| | *Limnodrilus* sp. | 2 | - | - | - | 24 | 26 | 2.10 |
| | Naidinae | - | - | - | 7 | - | 7 | 0.56 |
| | *Nais* sp. | 1 | - | - | - | - | 1 | 0.08 |
| | *Ophidonais serpentina* Müller, 1773 | - | 2 | - | 1 | 80 | 83 | 6.69 |
| | *Pristina* sp. | - | 1 | - | - | - | 1 | 0.08 |
| | *Psammoryctides albicola* (Michaelsen, 1901) | 7 | 5 | 28 | - | 188 | 228 | 18.38 |
| | *Psammoryctides deserticola* (Grimm, 1877) | 1 | 14 | - | - | 9 | 24 | 1.93 |
| | *Potamothrix hammoniensis* (Michaelsen, 1901) | 10 | - | 49 | - | 2 | 61 | 4.92 |
| | *Psammoryctides* sp. | 5 | 1 | - | - | 2 | 8 | 0.64 |
| | *Rhyacodrilus coccineus* (Vejdovsky, 1875) | - | 2 | - | - | - | 2 | 0.16 |
| | *Stylaria lacustris*Linnaeus, 1767 | - | - | - | 1 | - | 1 | 0.08 |
| | *Tubifex tubifex* (Müller, 1774) | 15 | 3 | 73 | 46 | 156 | 293 | 23.61 |
| | Tubificinae | 18 | 6 | 68 | 91 | 62 | 245 | 19.75 |
| | *Uncinais uncinata* (Ørsted, 1842) | - | 3 | 2 | - | - | 5 | 0.40 |
| | *Vejdovskyella intermedia* Bretscher, 1896) | 4 | - | - | - | - | 4 | 0.32 |
| **Total** | | 85 | 49 | 286 | 226 | 595 | 1241 | |
| **Dominance%** | | 6.85 | 3.95 | 23.05 | 18.21 | 47.95 | | |

With 595 individuals (47.95%), the ST5 had the highest number of individuals in all stations. It was followed by ST3 and ST4 with 286 individuals (23.05%) and 226 individuals (18.21%), while ST1 had 85 individuals (6.85%) and ST2 had 49 individuals (3.95%) in total (Table 2).

Depth values were ranged 19.75-46.5 cm; width values were ranged 174-6749 cm; flow rate values were ranged 0-0.85m/s; water temperature values were ranged 12.58-14.88°C; dissolved oxygen values were ranged 5.815-9.46 mg/L; pH values were ranged 7.73-8.08; conductivity values were ranged 130-1900 µS/cm; salinity values were ranged 0.045-1.31; TP values were ranged 86.93- 366.71 µg/L; o-PO4 values were ranged 22.66-186.47 µg/L; $NH_4$-N values were ranged <0.5- 4.99 mg/L; $NO_2$-N values were ranged 12.46-83.28 µg/L, $NO_3$-N values were ranged 0.24-0.54 mg/L and TSS values were ranged 0.17-2.08 g/L measured. The average of physicochemical parameter values is shown in Table 3.

When the physicochemical data were analysed seasonally, dissolved oxygen values were found to be of class III water quality at station 1 and class I at the other stations. Electrical conductivity values were of class III water quality at the first and 5th stations, class II water quality at the 2nd and class I at the other stations. Total phosphate was found to be class III at stations 1 and 5, class II at stations 2, 3 and 4, o-$PO_4$ was class III at stations 1, class I at stations 2 and 4, and class II at stations 3 and 5. $NH_4$-N was found to be class III water quality at the first station and class II at the other stations (TSWQR, 2021).

**Table 3.** Seasonal and average values of sampling stations

| RİVA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Unit** | **Spring** | **Summer** | **Autumn** | **Winter** | **Average** | **TSWQR, 2021** | **Quality Parameters** |
| **Depth** | cm | 36 | 34 | 371.4 | 24 | 32.75 | | |
| **Width** | cm | 6916 | 6578 | 6646 | 6676 | 6749 | | |
| **FR** | m/s | 0 | 0 | 0 | 0 | 0 | | |
| **Temp.** | °C | 11.5 | 24.5 | 18.1 | 5,4 | 14.88 | | |
| **DO** | mg/L | 4.82 | 3.46 | 3.47 | 11,5 | 5.81 | <6 | III |
| **pH** | - | 8.67 | 7.7 | 7.14 | 7,91 | 7.86 | | |
| **EC** | µS/cm | 2440 | 1120 | 3070 | 970 | 1900 | >1000 | III |
| **Salinity** | ppm | 1.25 | 2.4 | 1.4 | 0.2 | 1.31 | | |
| **TP** | µg/L | 265.74 | 569.39 | 476.28 | 155.43 | 366.71 | >0,2 | III |
| **o-$PO_4$** | µg/L | 43.47 | 332.82 | 293.67 | 75.92 | 186.47 | >0,16 | III |
| **$NH_4$-N** | mg/L | 3.12 | 6.55 | 9.45 | 0.83 | 4.99 | >1 | III |
| **$NO_2$-N** | µg/L | 77.08 | 104.37 | 108.23 | 43.43 | 83.28 | | |
| **$NO_3$-N** | mg/L | 0.46 | 0.22 | 0.33 | 0.73 | 0.44 | | |
| **TSS** | g/L | 2.5 | 3.1 | 1.93 | 0.79 | 2.08 | | |
| **KUZDERE** | | | | | | | | |
| | **Unit** | **Spring** | **Summer** | **Autumn** | **Winter** | **Average** | **TSWQR, 2021** | **Quality Parameters** |
| **Depth** | cm | 17 | 19 | 18 | 25 | 19.75 | | |
| **Width** | cm | 370 | 280 | 193 | 370 | 303.25 | | |
| **FR** | m/s | 1.2 | 0.2 | 0.2 | 0.6 | 0.55 | | |
| **Temp.** | °C | 10.5 | 21.5 | 17.7 | 5.8 | 13.88 | | |
| **DO** | mg/L | 9.7 | 5.82 | 4.7 | 13.76 | 8.50 | >8 | I |
| **pH** | - | 8.82 | 7.69 | 7.07 | 8.04 | 7.91 | | |
| **EC** | µS/cm | 410 | 600 | 440 | 320 | 422.5 | 1000 | II |
| **Salinity** | ppm | 0.34 | 0 | 0 | 0 | 0.09 | | |
| **TP** | µg/L | 218.06 | 66.59 | 79.89 | 85.13 | 112.42 | 0,2 | II |
| **o-$PO_4$** | µg/L | 20.38 | 15.22 | 28.23 | 26.79 | 22.66 | <0,05 | I |
| **$NH_4$-N** | mg/L | 0.59 | <0.5 | <0.5 | <0.5 | <0.5-0.59 | 1 | II |
| **$NO_2$-N** | µg/L | 18.12 | 42.36 | 55 | 8.37 | 30.96 | | |
| **$NO_3$-N** | mg/l | 0.6 | 0.27 | 0.39 | 0.41 | 0.42 | | |
| **TSS** | g/l | 0.4 | 0.4 | 0.28 | 0.16 | 0.31 | | |

| KANLIDERE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Unit** | **Spring** | **Summer** | **Autumn** | **Winter** | **Average** | **TSWOR, 2021** | **Quality Parameters** |
| **Depth** | cm | 24 | 17 | 20 | 47 | 27 | | |
| **Width** | cm | 297 | 267 | 220 | 490 | 318.5 | | |
| **FR** | m/s | 2.3 | 0.2 | 0.2 | 0.7 | 0.85 | | |
| **Temp.** | °C | 11.5 | 16.6 | 15.7 | 6.5 | 12.58 | | |
| **DO** | mg/L | 10.08 | 6.78 | 6.8 | 12.39 | 9.01 | >8 | I |
| **pH** | - | 8.88 | 6.32 | 7.16 | 9.63 | 8.00 | | |
| **EC** | µS/cm | 310 | 40 | 20 | 150 | 130 | <400 | I |
| **Salinity** | ppm | 0.17 | 0 | 0 | 0 | 0.04 | | |
| **TP** | µg/L | 50.46 | 46.95 | 186.1 | 64,19 | 86.93 | 0,2 | II |
| **o-$PO_4$** | µg/L | 12.79 | 8.54 | 83.12 | 37,05 | 35.38 | <0,05 | I |
| **$NH_4$-N** | mg/L | <0.5 | 0.59 | 0.82 | <0,5 | <0.5-<0.7 | <0,05 | II |
| **$NO_2$-N** | µg/L | 5.47 | 5.59 | 27.46 | 11,3 | 12.46 | | |
| **$NO_3$-N** | mg/L | 0.41 | 0.18 | 0.16 | 0,31 | 0.27 | | |
| **TSS** | g/L | 0.1 | 0.1 | 0.45 | 0.01 | 0.17 | | |
| **ATDOSUN** | | | | | | | | |
| | **Unit** | **Spring** | **Summer** | **Autumn** | **Winter** | **Average** | **TSWQR, 2021** | **Quality Parameters** |
| **Depth** | cm | 15 | 12 | 18 | 52 | 24.25 | | |
| **Width** | cm | 163 | 177 | 132 | 224 | 174 | | |
| **FR** | m/s | 0.4 | 0.15 | 0.2 | 0.2 | 0.24 | | |
| **Temp.** | °C | 11 | 21.6 | 15.9 | 4.4 | 13.23 | | |
| **DO** | mg/L | 10.34 | 8.83 | 6.02 | 12.65 | 9.46 | >8 | I |
| **pH** | - | 8.59 | 7.57 | 7.2 | 8.96 | 8.08 | | |
| **EC** | µS/cm | 580 | 10 | 40 | 250 | 220 | <400 | I |
| **Salinity** | ppm | 0.16 | 1.2 | 0 | 0 | 0.34 | | |
| **TP** | µg/L | 234.19 | 135.31 | 85.88 | 82.89 | 134.57 | 0,2 | II |
| **o-$PO_4$** | µg/L | 55.01 | 35.72 | 49.64 | 55.76 | 49.03 | >0,2 | I |
| **$NH_4$-N** | mg/L | 0.63 | 0.63 | <0.5 | <0.5 | <0.5-0.63 | <0,05 | II |
| **$NO_2$-N** | µg/L | 9.81 | 12,32 | 35.02 | 13.03 | 17.55 | | |
| **$NO_3$-N** | mg/l | 0.31 | 0,15 | 0.16 | 0.34 | 0.24 | | |
| **TSS** | g/l | 0.1 | 0,3 | 0.29 | 0.05 | 0.19 | | |
| **DEĞİRMENDERE** | | | | | | | | |
| | **Unit** | **Spring** | **Summer** | **Autumn** | **Winter** | **Average** | **TSWQR, 2021** | **Quality Parameters** |
| **Depth** | cm | 84 | 23 | 32 | 47 | 46.50 | | |
| **Width** | cm | 484 | 350 | 370 | 592 | 449 | | |
| **FR** | m/s | 0.2 | 0 | 0 | 0.12 | 0.08 | | |
| **Temp.** | °C | 12 | 24.9 | 16,2 | 5.4 | 14.63 | | |
| **DO** | mg/L | 7.58 | 5.52 | 6.76 | 12.57 | 8.11 | >8 | I |
| **pH** | - | 7.92 | 7.51 | 7.4 | 8.1 | 7.73 | | |
| **EC** | µS/cm | 550 | 390 | 1100 | 480 | 630 | 1000 | II |
| **Salinity** | ppm | 0.27 | 0.4 | 0.3 | 0 | 0.24 | | |
| **TP** | µg/L | 114.27 | 558.87 | 429.16 | 186.84 | 322.29 | >0,2 | III |
| **o-$PO_4$** | µg/L | 66.1 | 163.92 | 292.95 | 172.92 | 173.97 | 0,16 | II |
| **$NH_4$-N** | mg/L | 0.71 | 6.47 | 4.56 | <0.5 | 3.91 | 1 | II |
| **$NO_2$-N** | µg/L | 28.3 | 53.86 | 203.89 | 15.94 | 75.50 | | |
| **$NO_3$-N** | mg/l | 0.7 | 0.12 | 0.93 | 0.4 | 0.54 | | |
| **TSS** | g/l | 0.3 | 0.8 | 0.7 | 0.26 | 0.52 | | |

When the NPI values of the stations are analysed in terms of seasons

Spring season; ST3<ST2<ST4<ST1<ST5

Summer season; ST3<ST2<ST4<ST5<ST1

Autumn season; ST2<ST4<ST3<ST1<ST5

Winter season; ST2<ST3<ST4<ST1<ST5.

NPI values were found as no pollution at station 3 in the spring season and moderate pollution at other stations. In the summer season, stations 2, 3, and 4 were no pollution, while stations 1 and 5 were considerably polluted. In autumn, station 2 was not polluted while stations 3 and 4 were moderately polluted. In this season, stations 1 and 5 were considerably polluted. In the winter season, stations 1, 2, 3, and 4 were found to be moderately polluted. In the same season, station 5 was found to be considerably polluted. According to the NPI index, Riva and Değirmendere were more polluted than other streams (Table 4).

**Table 4.** NPI Indices of the stations in terms of seasons

| | ST1 | ST2 | ST3 | ST4 | ST5 |
|---|---|---|---|---|---|
| **Spring** | 1.478 | 1.285 | 0.804 | 1.456 | 2.232 |
| **Summer** | 6.924 | 0.598 | 0.425 | 0.753 | 3.377 |
| **Autumn** | 6.286 | 0.975 | 1.836 | 1.036 | 7.170 |
| **Winter** | 2.477 | 1.004 | 1.057 | 1.501 | 3.990 |

When the stream waters are evaluated regarding physicochemical parameters, the 2nd and 3rd stations are the most similar (76.37%). The 4th station joins this similarity. ST1 and ST3 were the least similar stations (12.75%) (Figure 4a).

When the similarity of the taxa detected in the sampling stations in terms of stations was analysed, it was seen that the 3rd and 4th stations were the most similar stations with a rate of 61.71%. The 5th station participates in this similarity. ST2 and ST5 were the least similar stations (9.31%) (Figure 4b).

The CCA triplot shows that lines represent environmental variables and dots represent taxa (Figure 5).

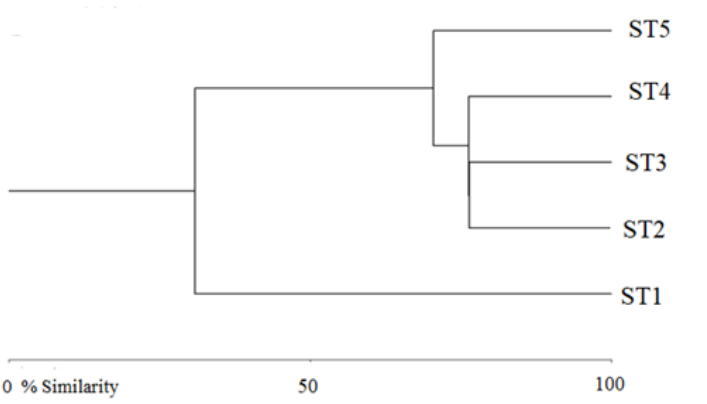



**Figure 4a.** The similarity of the stations in terms of physicochemical parameters

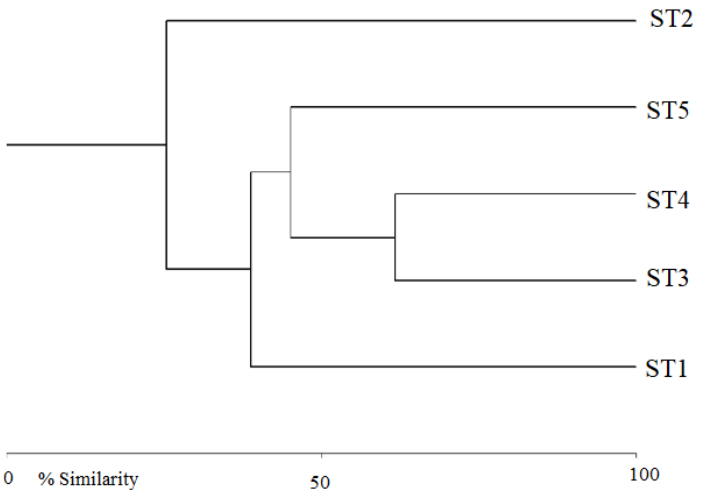



**Figure 4b.** Similarity of the stations in terms of taxons

Two axes, 43.44% (first Axis) and 24.29% (second Axis), explain a total of 67.73%. The CCA triplot shows that the species distributed parallel to the second axis, and width, salinity and TSS values were closest to the second axis. Considering the triplot, TSS was found to be the key parameter for the distribution of taxa. *U. uncinata* and *L. hoffmeisteri* appeared closely related to salinity, while *E. tetraedra, H. naidina, H. stagnalis, P. deserticola* and *Nais* sp. were shown closely related to width (Figure 5). *L.udekemianus* was not found in the main tributary, which is quite different from the other stations regarding physical and chemical properties. The CCA triplot given in Figure 5 shows that the distribution of this species and the salinity value were positioned oppositely. Both measurements and statistical analysis show that salinity should be important in the distribution of this species.

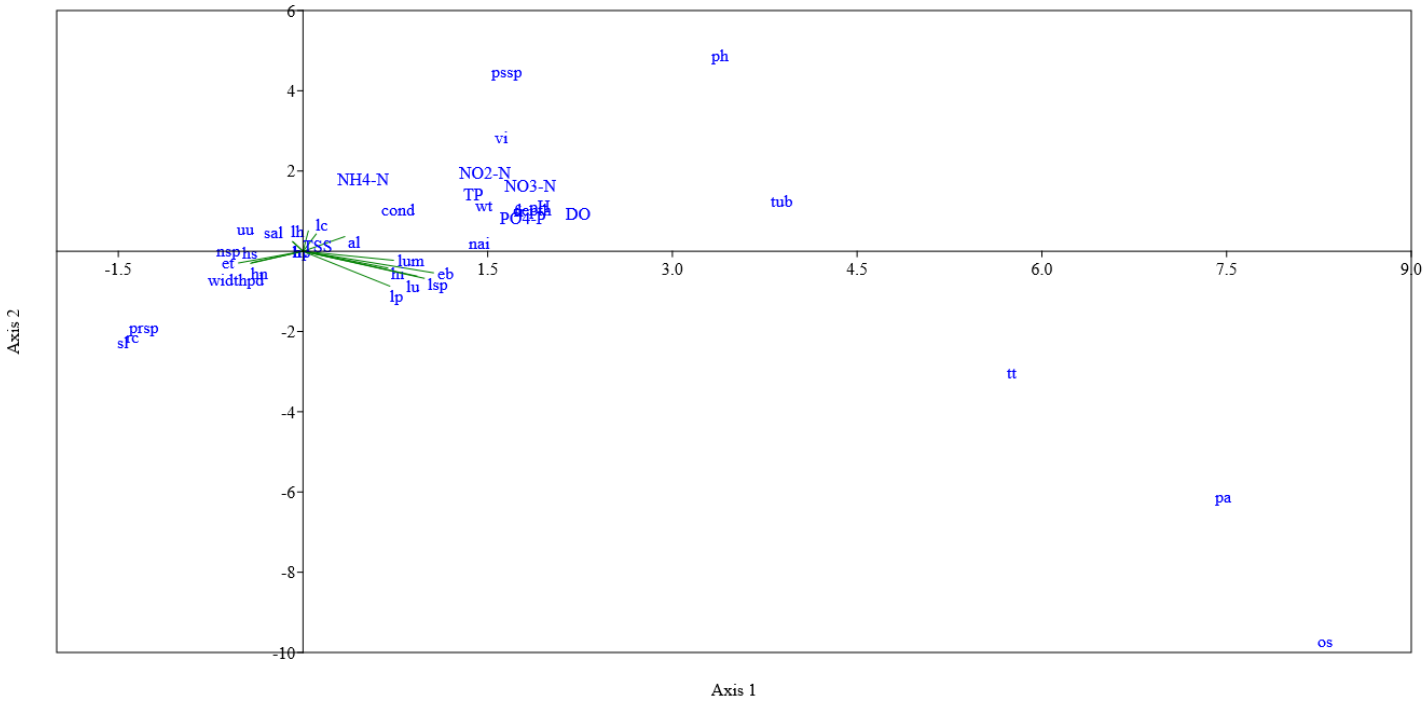



**Figure 5.** CCA triplot [*Abbrv.: Lum:* Lumbricidae*; et: E. tetraedra; hs: H. stagnalis; hv: H. ventriculosa; hp: H. perpusilla; eb: E. buchholzi; hi:* Hirudinea*; al: A. limnobius; hn: H. naidina; lc: L. claparedeanus; lp: L. profundicola; lh: L. hoffmeisteri; lu: L. udekemianus; lsp: Limnodrilus* sp.*; nai:* Naidinae*; nsp: Nais* sp.*; os: O. serpentina; prsp: Pristina* sp.*; pa: P. albicola; pd: P. deserticola; ph: P. hammoniensis; pssp: Psammoryctides* sp.*; rc: R. coccineus; sl: S. lacustris; tt: T. tubifex; tub:* Tubificinae*; uu: U. uncinata; Vi: V. intermedia;* wt: water temperature, sal: salinity, TSS: suspended solid, cond: conductivity, fr: flow rate]

Our study can be compared with previous studies conducted in the Riva stream. Karadeniz (2007) reported that the pH of the stream varied between 6.7-8.54. Uzun (2012) reported that the pH varied between 7.08 and 7.68. Compared to our study, it can be said that the water of the Riva stream is slightly more basic. Karadeniz (2007) reported that the temperature of the stream was between 4-26.7°C; Uzun (2012) reported that it was between 8.51-26.26°C. It is seen that there is not much change between the temperature values, and the values are close to each other in these three studies. When compared with our study, it was reported that the water of the Riva stream was slightly more basic and dissolved oxygen values varied between 0.6-7.8 mg/L by Karadeniz (2007) and between 2.16-5.77 mg/L by Uzun (2012). In our study, dissolved oxygen values were higher than in other studies. Electrical conductivity values were reported to vary between 292-1725 µS/cm by Karadeniz (2007) and 537-2164 µS/cm by Uzun (2012). Our study shows that electrical conductivity values are quite high in Riva and Değirmendere (Table 3). Conductivity, which is a measure of the electrical capacity of water, expresses the change in the concentration of dissolved solids in water (Kara & Çömlekçioğlu, 2004). Both the rock structure in the riverbed and pollution can affect the electrical conductivity of water (Barlas, 1988).

As the temperature increases, the concentration of dissolved ions increases due to evaporation and electrical conductivity increases (Durhasan, 2006). Karadeniz (2007) reported that $PO_4$-P values vary between 1.06-3.54 mg/L. In our study, it is seen that o-$PO_4$ values are quite high (Table 3).

When the study found similar results compared with previous studies, Odabaşı et al. (2018) investigated the aquatic oligochaeta fauna of the Biga Peninsula rivers and their seasonal changes. They reported that 33 taxa belonged to oligochaeta. They found that the pH and $NO_3$-N values of the streams were in the 1st class quality, and the EC, DO, and BOD values were between the 1st and 2nd class water quality. Albayrak et al.

(2023) determined 9 taxa from oligochaeta in their study in Göksu stream. They reported that the DO values of the stream are between the 1st and 2nd class, EC values are in the 2nd class, TP values in the 3rd class, o-$PO_4$ values in the 1st class, and $NH_4$-N values in the 2nd class.

As a result, high electrical conductivity and o-$PO_4$ values can be attributed to increased pollution load in the streams. In this study, while the first records were given for Kuzdere, Kanlıdere, Atdosun and Değirmendere, time-dependent changes were presented for Riva.

## Conclusion

In terms of water quality, Kuzdere, Kanlıdere, and Atdosun can be considered as potable water. However, water use from these areas is not recommended until monitoring continues and good-quality water is identified.

Riva and Değirmendere were found to be heavily polluted both physically and chemically. Both physicochemical parameters and the NPI index supported this. For these stations, where only tolerant species can shelter, pollution sources should be identified, and these sources should be cut. As one of these stations is a main tributary and is close to the sea, protecting the entire settlement pattern around the Riva Stream and all biological elements, including marine life is of utmost priority. It is recommended that the investigations continue along the stream following the main tributary and that the pollution status be determined in other tributaries.

**Compliance with Ethical Standards**

**Conflict of interest:** The authors declare no actual, potential, or perceived conflict of interest for this article.

**Ethics committee approval:** Ethics committee approval is not required for this study.

**Data availability:** Data will be made available on request.

**Funding disclosure:** No funding provided.

**Acknowledgements:** We thank Istanbul University Institute of Graduate Studies in Sciences and Istanbul University Faculty of Aquatic Sciences Inland Water Laboratory for their valuable contributions.

**Disclosure:** This study is based on a part of the Ph.D. dissertation.

## References

**Albayrak, E., Koşal Şahin, S., Taş Divrik, M. & Odabaşı, S. (2023).** Some physicochemical parameters and Oligochaeta fauna of Göksu stream (Istanbul, Turkey), *Review of Hydrobiology*, 16(1-2).

**Akay, E., Dalkıran, N. & Dere, Ş. (2018).** Akarsuların Biyolojik Su Kalitesinin Belirlenmesinde Bentik Makroomurgasızların Kullanımı, *İklim Değişikliği ve Çevre,* 3(1), 60-67.

**Akkaya, E. (2003).** Ömerli Havzası'nda Kirlenme Eğilimi ve Fosfor Modeli Uygulaması, Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi, Fen Bilimleri Enstitüsü, 143p.

**Anonymous, (2014).** Annual Report, General Directorate of Istanbul Water and Sewerage Administration (2014).

**APHA, AWWA & WPCF. (1985).** Standard Methods for the Examination of Water and Wastewater, 16th Edition, Greenberg A. E., Trussel, R. R., Clesceri, L. S., Franson M.A.H. Washington.

**Arslan, N. (2006).** Records of Aphanoneura and Aquatic Oligochaetes from Türkiye, *Fresenius Environmental Bulletin*, Volume 15(4), 249–254.

**Arslan, N. & İlhan, S. (2010).** Distribution and Abundance of Clitellata (Annelida) Species and Environmental Variables of Porsuk Stream (Sakarya River, Turkey). *Review of Hydrobiology*, 3(1), 51-63.

**Aydın, G.B. & Çamur Elipek, B. (2019).** Benthic Macroinvertebrate Diversity of Rice Fields in the Meriç-Ergene River Basin, Thrace, Türkiye. *Acta Zoologica Bulgarica*, 71(1), 87-94.

**Barlas, M. (1988).** Limnologische Untersuchungen an der Fulda unter besonderer Berücksichtigung der Fischparasiten. İhrer Wirtsspektren under Wassengüte. Dissertation Universitat Kassel.

**Bellan-Santini, D. (1969).** Contribution à l'étude des peuplements infralittoraux sur substrats rocheux (étude qualitative et quantitative de la frange supérieure). Recl Trav. Stn mar. Endoume, 47(63), 5–294.

**Bo, T., Doretto, A., Laini, A., Bona, F. & Fenoglio, S. (2017).** Biomonitoring with macroinvertebrate communities in Italy: What happened to our past and what is the future? Journal of Limnology, 76(1), 21–28.

https://doi.org/10.4081/jlimnol.2016.1584

**Brinkhurst, R.O. & Jamieson, B.G.M. (1971).** Aquatic Oligochaeta of the World. Oliver and Boyd, Edinburg, UK., 860p.

**Brinkhurst, R.O. (1975).** Oligochaeta, In: F.K. Parrish (Ed.), Keys to the Water Quality Indicative Organisms of the South-Eastern United States. Cincinnati, OH, U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, USA, 69-85.

**Brinkhurst, R.O. (1986).** Guide to the Freshwater Aquatic Microdrile Oligochaetes of North America. *Canadian Special Publication of Fisheries and Aquatic Sciences*, 84, 1-259.

**Chapman, P.M., Farrell, M.A.& Brinkhurst, R.O. (1982).** Relative tolerance of selected aquatic oligochaetes to individual pollutants and environmental factors. *Aquatic Toxicology*, 2(1), 47–67.
https://doi.org/10.1016/0166-445X(82)90005-4

**Demiroğlu, G. & Mısıroğlu, M. (2010).** Eskişehir ve civarı Hirudinea faunası üzerine bir ön araştırma, *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi*, 9(17), 19-25.

**Demirsoy, A. (2005).** Yaşamın Temel Kuralları (Omurgasızlar=İnvertebrata)-Böcekler Dışında-Cilt-2 (Kısım-1), 1210 p.

**Durhasan, D. (2006).** Baraj Göllerinden Su Temininde Derinliğin Su Kalitesine Etkileri, Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 68p.

**Fındık, Ö. (2013).** Araç çayı makroomurgasızları üzerine Bbir ön çalışma. *Nevşehir Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 2 (1), 41-45.

**Hammer, O., Harper, D. A.T. & Ryan, P.D. (2001).** PAST: Paleontological Statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1), 4-99.

**Hare, L. & Shooner, F. (1995).** Do Aquatic Insects Avoid Cadmium Contaminated Sediments? Environmental Toxicology and Chemistry, 14, 1071–1077.
https://doi.org/10.1002/etc.5620140619

**Isiuku, B.O. & Enyoh, C.E. (2020).** Pollution and health risks assessment of nitrate and phosphate concentrations in water bodies in South Eastern Nigeria. *Environmental Advances*, 2, 100018.
https://doi.org/10.1016/j.envadv.2020.100018

**IIHR (2023)**. IIHR—HydroscienceEngineering www.iihr.uiowa.edu/ (accessed 1.6.2023).

**Kara, C. & Çömlekçioğlu, U. (2004).** Karaçay'ın (Kahramanmaraş) Kirliliğinin Biyolojik ve Fizikokimyasal Parametrelerle İncelenmesi. *KSÜ Fen ve Mühendislik Dergisi*, 7(1), 1-7.

**Karadeniz, Ş. (2007).** Riva Deresi'nin Bazı Fiziksel, Kimyasal ve Biyolojik Özelliklerinin Belirlenmesi, Marmara Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 79p.

**Kathman, R.D. & Brinkhurst, R.O. (1998).** Guide to the Freshwater Oligochaetes of North America. New England Interstate Water Pollution Control Commission through Grant Number 0240-006. 264p.

**Koşal Şahin, S. & Yıldız, S. (2011).** Species Distribution of Oligochaetes Related to Environmental Parameters in Lake Sapanca (Marmara Region, Türkiye). *Turkish Journal of Fisheries and Aquatic Sciences*, 11, 359-366.
https://doi.org/10.4194/1303-2712-v11_3_04

**Krebs, J.C. (1999).** Ecological methodology. Addison Wesley Longman, Inc., Menlo Park, California, ISBN: 0321021738/9780321021731.

**Langbein, W.B., & Iseri, K.T. (1995).** "Hydrologic Definitions: Stream". Manual of Hydrology: Part 1. General Surface-Water Techniques (Water Supply Paper 1541-A). Reston, VA: USGS.

**Larrea-Murrell, J.A., Romeu-Alvarez, B., Lugo-Moya, D. & Rojas-Badia, M.M. (2022).** Acid phosphatese activity in freshwater ecosystems of western Cuba and its relationship with water quality. *Water, Air, Soil Pollution,* 233. 57.
https://doi.org/10.1007/s11270-022-05514-y

**McAleece, N., Gage, J.D.G., Lambshead, P.J.D. & Paterson, G.L.J. (1997).** BioDiversity professional statistic analysis software. Jointly developed by the Scottish Association for Marine Science and the Natural History Museum London.

**Milbrink, G. (1973).** On the use of indicator communities of Tubificidae and some Lumbriculidae in the assessment of water pollution in Swedish lakes. *Zoon*, 1, 125–139.

**Odabaşı, S., Cirik, S. & Arslan, N. (2018).** Aquatic Oligochaeta (Annelida: Clitellata) Assemblages in the Streams of Biga Peninsula (Marmara-Türkiye) and Their Seasonal Variations. *Çanakkale Onsekiz Mart University Journal of Marine Sciences and Fisheries*, 1(2), 72-80.

**Özbek, M., Taşdemir, A., Aydemir Çil, E., Somek, H. & Yıldız, S. (2018).** Assessing the Trophic Level of a Mediterranean Stream (Nif Stream, İzmir) Using Benthic Macro-Invertebrates and Environmental Variables. *Turkish Journal of Fisheries. & Aquatic Sciences* 19(3), 179-190. https://doi.org/10.4194/1303-2712-v19_3_01

**Pamukçu, P. (2011).** İstanbul-Riva Deresi ve Çevresinin Peyzaj Potansiyelinin İrdelenmesi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 162p.

**Phillips, A.J., Govedich, F.R. & Moser, W.E. (2020).** Leeches in the extreme: Morphological, physiological, and behavioural adaptations to inhospitable habitats. International Journal for Parasitology: Parasites and Wildlife, Volume 12, 318-325p. ISSN 2213-2244. https://doi.org/10.1016/j.ijppaw.2020.09.003

**Särkkä, J. (1994).** Lacustrine, profundal meiobenthic oligochaetes as indicators of trophy and organic loading. *Hydrobiologia*, 278, 231-241. https://doi.org/10.1007/978-94-011-0842-3_26

**Selçuk, S. & Ongan, T. (1991).** Riva deresi'nin fiziksel kimyasal ve biyolojik özellikleri, *İstanbul Üniversitesi Su Ürünleri Dergisi*, 2, 53-70.

**Tarkan, A.S. (2007).** Ömerli Baraj Gölü'ne Akan Derelerin Fiziksel, Kimyasal ve Biyolojik Özelliklerinin İncelenmesi, Doktora Tezi, İstanbul Üniversitesi, Fen Bilimleri Enstitüsü.

**Taş, M., Çamur-Elipek, B., Kirgiz T., Arslan, N. & Yıldız, S. (2012).** The Aquatic and semi-aquatic Oligochaeta fauna of Turkish Thrace. *Journal of Fisheries Sciences*, 6(1), 26-31. https://doi.org/10.3153/jfscom.2012004

**Timm, T. (1970).** On the fauna of the Estonian Oligochaeta. *Pedobiologia*, 10(1), 52-78. https://doi.org/10.1016/S0031-4056(23)00398-0

**Timm, T. (1980).** Distribution of Aquatic Oligochaetes. In: Brinkhurst, R.O. and Cook, D. G. (eds) Aquatic Oligochaeta Biology., Plenum Press, New York, pp. 55–77. https://doi.org/10.1007/978-1-4613-3048-6_6

**Timm, T. (2009).** A Guide to the Freshwater Clitellata and Polychaeta of Northern and Central Europe. *Lauterbornia*, 66, 1-235.

**TSWOR (2016).** Turkish Surface Water Quality Regulation, Official Gazette no, 29797, Turkey.

**TSWQR (2021).** Turkish Water Quality Regulation, Official Gazette No, 28483, Turkey.

**Uzun, H.İ. (2012).** Riva Deresi Su Kalitesinin Belirlenmesi ve İstatistiksel Analizi, Sakarya Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 81p.

**Wetzel, M.J., Fend, S.V., Coates, K.A., Kathman, R. D. & Gelder, S.R. (2009).** Taxonomy, systematics, and ecology of the freshwater Oligochaetes and Branchiobdellidans (Annelida, Clitellata) of North America. A Workbook, 1 August 2009.

**Wetzel, M.J., Kathman, R.D., Fend, S.V. & Coates, K.A. (2000).** Taxonomy, Systematics and Ecology of Freshwater Clitellata. Workbook Prepared for North american Benthological Society Technical Information Workshop, 48th Annual Meeting, Keystone Resort, CO. 120 pp.

AQUATIC RESEARCH
E-ISSN 2618-6365



The journal "**AQUATIC RESEARCH**" establishes the highest standards of publishing ethics and benefits from the contents of the **International Committee of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME), Council of Science Editors (CSE), Committee on Publication Ethics (COPE), European Association of Science Editors (EASE), Open Access Scholarly and Publishers Association (OASPA),** and **Directory of Open Access Journals (DOAJ).**

All authors submitting their works to the "**AQUATIC RESEARCH**" journal for publication as original articles attest that the submitted works represent their authors' contributions and have not been copied or plagiarised in whole or in part from other works. The authors acknowledge that they have disclosed all and any actual or potential conflicts of interest with their work or its partial benefits. Similarly, the "**AQUATIC RESEARCH**" journal is committed to objective and fair double-blind peer review of the submitted works for publication and to preventing any actual or potential conflict of interest between the editorial and review personnel and the reviewed material.



## Journal Publisher Policy

### 1. Aims and Scope

**"Aquatic Research"** journal aims to contribute to the world of science with high-quality publications based on scientific research on aquatic ecosystems. The journal focuses on a wide range of topics, including aquaculture, sustainable water resources management, aquatic biology, marine ecology, and articles covering all fields of aquatic sciences. The journal's publication language is English or Turkish.

### 2. Scientific Quality and Objectivity

The journal evaluates and publishes research articles and reviews, adhering to high scientific standards. Adhering to the principle of impartiality, it strictly complies with ethical rules to prevent conflicts of interest among editors, referees, and authors.

### 3. Open Access

The journal adopts an open-access policy that supports open and free access to information. This aims to increase access to scientific knowledge in society at large by making science available to a wider audience.

5. **Ethical Standards**

The journal maintains a rigorous attitude towards upholding ethical standards among authors and reviewers. The processes of evaluating the effects of research on humans, animals and the environment are carried out in full compliance with national and international ethical rules.

6. **Peer Review**

The journal employs a double-blind referee system. Referees are selected among experts and experienced people in their fields. The peer review process involves subjecting articles to rigorous review in terms of scientific content, methodology and ethics.

7. **Author Rights and Licensing**

The journal respects the property rights of authors and grants appropriate licenses to articles. It allows articles to be freely shared and used by others using appropriate licensing models, such as Creative Commons licenses.

8. **Diversity and Inclusion**

The journal encourages diversity among authors, editors, and reviewers. It fights against inequalities in the scientific world, considering gender, geographical origin, discipline, and other elements of diversity.

9. **Communication and Transparency**

The journal promotes open communication between authors, reviewers and readers. Publisher policies, article evaluation processes and other important information are transparently published on the journal's website.

10. **Archiving**

Journal archiving is conducted following the **Republic of Türkiye Ministry of Industry and Technology TÜBİTAK Turkish Academic Network and Information Center (ULAKBİM)** "DergiPark" publication policy (LOCKSS).

## Publication Ethics

1. **Scientific Neutrality and Objectivity:**

All publications must reflect an impartial and objective perspective. If there are any conflicts of interest, authors must clearly state these conflicts of interest.

2. **Scientific Soundness:**

Articles should be based on a solid methodology and reliable results. The accuracy of statistical analyses should be at the forefront.

3. **Ethical Standards:**

The journal supports the principles of the Basel Declaration (https://animalresearchtomorrow.org/en) and the guidelines published by the International Council for Laboratory Animal Science (https://iclas.org/). In this regard, the research must fully comply with the relevant ethical rules and standards. International ethics committees must conduct studies on humans, animals, or the environment and must be confirmed by the authors of the journal.

For research submitted to this journal, authors are advised to comply with the **IUCN Policy Statement on Research Involving Species at Risk of Extinction and the Convention on Trade in Endangered Species of Wild Fauna and Flora for research involving plants.**

4. **Originality and Plagiarism:**

Publications must be original, and appropriate attribution must be made when quoting other sources. In our journal, plagiarism is considered a serious crime. For this reason, all articles submitted to the "Aquatic Research" journal must undergo a preliminary evaluation. Advanced Plagiarism Detection Software (iThenticate, etc.) tools will be used.

5. **Open Access:**

   The journal adopts open access principles to promote open and free access to information and complies with the Budapest Open Access Initiative (BOAI) definition of open access. Open-access articles in the journal are licensed under the terms of the Creative Commons Attribution 4.0 International (CC BY 4.0) license.

   All journal processes are free of charge. No article processing, submission, or publication fee is charged for submitted or accepted articles.

## Peer Review

1. **Confidentiality:**

   The peer review process should be carried out per the principles of double-blind refereeing. Reviewers and authors should not know each other's identities.

2. **Expertise:**

   Referees should be selected among experts and experienced people in relevant fields. Referees must be trusted to make an impartial and ethical assessment.

3. **Timely Evaluation:**

   The peer-review process must be completed on time to publish the articles quickly. Time limits should be set for referees to evaluate within a certain period.

4. **Open Communication:**

   Reviewers should be encouraged to provide open and constructive feedback to authors and editors.

## Author Guidelines

1. **Article Format:**

   Authors must write in the article format determined by the journal. Sections such as title, abstract, keywords, introduction, method, findings, discussion and references should be included. All submissions are screened by similarity detection software. The similarity rate in the articles sent to the journal should be below 20%.

2. **Citations and Sources:**

   Authors must appropriately cite the sources used by scientific standards.

3. **Submission Process:**

   Authors must comply with the specified submission process when submitting their articles to the journal. This process should include evaluating, editing and publishing the article.

   Manuscripts can only be submitted through the journal's online manuscript submission and evaluation system, available at http://dergipark.gov.tr/journal/2277/submission/start.

   "**Aquatic Research**" journal requires corresponding authors to submit a signed and scanned version of the copyright transfer, ethics, and authorship contribution form (available for download at https://dergipark.org.tr/en/download/journal-file/19583)

   ICMJE Potential Conflict of Interest Disclosure Form (should be filled in by all contributing authors) Download this form from http://www.icmje.org/conflicts-of-interest/ fill and save. Send this to the journal with your other files.

4. **Research Funding and Conflicts of Interest:**

   Research funding sources and conflicts of interest should be clearly stated. It is important to disclose and not conceal conflicts of interest.

AQUATIC
RESEARCH
E-ISSN 2618-6365



5. **Language:**

   Articles should be written to a scientific journal standard, and care should be taken regarding grammar and spelling errors.

## Editors' Responsibilities

1. **Maintaining High Scientific Standards:**

   To ensure that the articles published in the journal comply with high scientific standards.

   To ensure full compliance with ethical rules and journal policies.

2. **Managing the Article Evaluation Process:**

   To effectively manage the article evaluation process and support a rapid publication process.

   To adopt the principles of double-blind arbitration and maintain the principles of expertise and impartiality in selecting arbitrators.

3. **Making Editorial Decisions:**

   Consider referee evaluations to make decisions about accepting or rejecting articles for publication.

   Maintaining transparency and openness in the editorial process.

4. **Contact with Authors:**

   Maintaining effective and constructive communication with authors.

   They provide authors with regular updates on the status of their articles, correction requests, and publication dates.

5. **Managing Journal Policies:**

   Keep the journal's policies and guidelines updated and revise them as needed.

   To provide a reliable platform between readers and writers.

## Responsibilities of Referees

1. **Objectivity and Expertise:**

   To comply with the principles of double-blind refereeing and to evaluate articles impartially.

   Evaluating articles by focusing on areas of expertise on the subject.

2. **Privacy and Reliability:**

   To protect the confidentiality of the article evaluation process.

   Provide reliable and constructive feedback to authors, journal editors, and other reviewers.

3. **Timely Evaluation:**

   Evaluating articles by the timelines determined by the journal.

   Informing editors promptly in case of delays.

4. **Compliance with Ethical Rules:**

   To ensure full compliance with ethical standards and journal policies.

   Clearly express conflicts of interest and withdraw from the evaluation process when necessary.

5. **Constructive Feedback to Writers:**

   Provide clear and constructive feedback to authors and suggest improving the article when necessary.

## Preparation of the Manuscript

**Manuscripts prepared in Microsoft Word must be converted into a single file before submission. Please start with the title page and insert your graphics (schemes, figures, *etc.*) and tables in the one main text (Word Office file).**

**Title (should be clear, descriptive, and not too long)**

**Full Name(s) and Surname (s) of author(s)**

**ORCID ID for all author (s) (http://orcid.org/)**

**Authors complete correspondence Address (es) of affiliations and e-mail (s)**

**Abstract**

**Keywords (indexing terms), usually 3-6 items**

**Introduction**

**Material and Methods**

**Results and Discussion**

**Conclusion**

**Compliance with Ethical Standards**

- **Conflict of Interest:** When you (or your employer or sponsor) have a financial, commercial, legal, or professional relationship with other organisations or people working with them, a conflict of interest may arise that may affect your research. A full description is required when you submit your article to a journal.
- **Ethics committee approval:** Ethical committee approval is routinely requested from every research article based on experiments on living organisms and humans. Sometimes, studies from different countries may not have the ethics committee's approval, and the authors may argue that they do not need support for their work. In such situations, we consult COPE's "Guidance for Editors: Research, Audit, and Service Evaluations" document, evaluate the study with the editorial board, and decide whether or not it needs approval.
- **Data availability:** The data availability statement/data access statement informs the reader where research data associated with an article is available and under what conditions the data can be accessed, and may include links to the dataset, if any.

  **One of the following should be selected and stated in the submitted article;**

1. No data was used for the research described in the article.
2. The data that has been used is confidential.
3. The authors do not have permission to share the data.
4. Data will be made available on request.
5. The author is unable to specify which data has been used or has chosen not to.
6. Other (please explain; for example, I have shared the link to my data in the attached file step).

- **Funding:** If there is any, the institutions that support the research and the agreements with them should be given here.
- **Acknowledgment:** Acknowledgments allow you to thank people and institutions who assist in conducting the research.
- **Disclosure:** Explanations about your scientific / article work that you consider ethically important.

**References**

**Tables (all tables given in the main text)**

**Figures (all figures/photos shown in the main text)**

### Manuscript Types

**Original Articles:** This is the most essential type of article since it provides new information based on original research. The main text should contain **"Title", "Abstract", "Introduction", "Materials and Methods", "Results and Discussion", "Conclusion", "Compliance with Ethical Standards**", and **"References" sections.**

Statistical analysis to support conclusions is usually necessary. International statistical reporting standards must conduct statistical analyses. Information on statistical analyses should be provided with a separate subheading under the Materials and Methods section, and the statistical software used during the process must be specified.

Units should be prepared by the International System of Units (SI).

**Review Articles:** Reviews prepared by authors with extensive knowledge of a particular field

and whose scientific background has been translated into a high volume of publications with a high citation potential are welcomed. The journal may even invite these authors. Reviews should describe, discuss, and evaluate the current knowledge level of a research topic and should guide future studies. The main text should start with the Introduction and end with the Conclusion sections. Authors may choose to use any subheadings in between those sections.

**Short Communication:** This type of manuscript discusses important parts, overlooked aspects, or lacking features of a previously published article. Articles on subjects within the journal's scope that might attract the readers' attention, particularly educative cases, may also be submitted as a "Short Communication". Readers can also comment on the published manuscripts as a "Short Communication". The main text should contain **"Title", "Abstract", "Introduction", "Materials and Methods", "Results and Discussion", "Conclusion", "Compliance with Ethical Standards**", and **"References"** sections.

**Table 1.** Limitations for each manuscript type

| Type of manuscript | Page | Abstract word limit | Reference limit |
|---|---|---|---|
| Original Article | ≤30 | 200 | 40 |
| Review Article | no limits | 200 | 60 |
| Short Communication | ≤5 | 200 | 20 |

## Tables

Tables should be included in the main document and presented after the reference list, and they should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables. Abbreviations in the tables should be defined below them by footnotes (even if they are defined within the main text). Tables should be created using the "insert table" command of the word processing software and arranged clearly to provide easy reading. Data presented in the tables should not be a repetition of the data presented within the main text but should support the main text.

## Figures and Figure Legends

Figures, graphics, and photographs should be submitted through the submission system in the main document's Word files (in JPEG or PNG format). Any information within the images that may indicate an individual or institution should be blinded. The minimum resolution of each submitted figure should be 300 DPI. To prevent delays in the evaluation process, all submitted figures should be clear in resolution and large (minimum dimensions: 100 × 100 mm). Figure legends should be listed at the end of the primary document.

All acronyms and abbreviations used in the manuscript should be defined at first use, both in the abstract and in the main text. The abbreviation should be provided in parentheses following the definition.

When a drug, product, hardware, or software program is mentioned within the main text, product information, including the name of the product, the producer of the product, and city and the country of the company (including the state if in the USA), should be provided in parentheses in the following format: "Discovery St PET/CT scanner (General Electric, Milwaukee, WI, USA)."

All references, tables, and figures should be referred to within the main text and numbered consecutively in the order they are referred to within it.

Limitations, drawbacks, and shortcomings of original articles should be mentioned in the Discussion section before the conclusion paragraph.

## References

**The citation style and methods that comply with the scientific standards that should be used in the "Aquatic Research" journal for the sources used by the authors in their works are given below.**

Reference System is APA 6$^{th}$ Edition (with minor changes)

The APA style calls for three kinds of information to be included in in-text citations. The author's last name and the work's publication date must always appear, and these items must match exactly the corresponding

entry in the references list. The third kind of information, the page number, appears only in a citation to a direct quotation.

....(Bhujel, 2014).

....(Mol & Erkan, 2009).

....(Alofa et al., 2023).

....(Mol & Erkan, 2009; Bhujel, 2014; Alofa et al., 2023).

**Citations for a Reference Section:**

An article

**Alofa, C.S., Olodo, I.Y., Chabi Kpéra Orou Nari, M., Abou, Y. (2023).** Effects of the fresh and dried housefly (*Musca domestica*) larvae in the diets of Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758): growth, feed utilisation efficiency, body composition, and biological indices. *Aquatic Research*, 6(1), 1-10. https://doi.org/10.3153/AR23001
**(if a DOI number is available)**

A book in print

**Bhujel, R.C. (2014).** A manual for tilapia business. CABI Nosworthy Way Wallingford Oxfordshire OX10 8DE UK, 199 p. ISBN 978-1-78064-136-2. https://doi.org/10.1079/9781780641362.0000
**(if a DOI number is available)**

A book chapter

**Craddock, N. (1997).** Practical management in the fo od industry A case study. In Food Allergy Issues for th e Food Industry; Lessof, M., Ed.; Leatherhead Food R A: Leatherhead, U.K., pp 25-38. ISBN: 4546465465

A webpage

**CDC (2020).** Rift Valley Fever | CDC. https://www.cdc.gov/vhf/rvf/index.html (accessed 20.08.2020).

**Revisions**

When submitting a revised version of a paper, the author must submit a detailed "Response to the reviewers" that states point by point how each issue raised by the reviewers has been covered and where it can be found (each reviewer's comment, followed by the author's reply and line numbers where the changes have been made) as well as an annotated copy of the main document. Revised manuscripts must be submitted within 15 days from the date of the decision letter. If the revised version of the manuscript is not submitted within the allocated time, the revision option may be cancelled. If the submitting author(s) believe that additional time is required, they should request this extension before the initial 15-day period is over.

Accepted manuscripts are copy-edited for grammar, punctuation, and format. Once the publication process of a manuscript is completed, it is published online on the journal's webpage as an ahead-of-print publication before it is included in its scheduled issue. A PDF proof of the accepted manuscript is sent to the corresponding author, and their publication approval is requested within two days of their receipt of the proof.