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Alabalık Yetiştiricilik Tesislerinde İş Sağlığı ve Güvenliği Risk Analizi

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Öz- Alternatif gıda arzına cevap veren su ürünleri sektörü her geçen gün katlanarak büyümeye devam etmektedir. Bu nedenle su ürünleri yetiştiricilik tesislerinde artan iş yükünü karşılayacak insan gücüne ihtiyaç vardır. Her sektörde olduğu gibi su ürünleri yetiştiriciliğinde de çalışanlar için iş sağlığı ve güvenliği oldukça önemlidir. Mevcut çalışma, entegre bir alabalık yetiştirme tesisinde meydana gelebilecek vaka senaryolarına odaklanmıştır. Bu kapsamda toplam 79 farklı vaka senaryosu için uzman görüşleri değerlendirilmiştir. 5x5 matris yöntemi ile analiz edilen vaka senaryoları, tesis genelinde, kültür tanklarında, tuvaletlerde ve yem depolarında yüksek riskli vakaların oluşabileceğini göstermiştir. Tüm vaka senaryolarında en fazla risk sayısı orta risk kategorisinde gözlenmiştir. Orta risk kategorisinde, özellikle tesis için öngörülen vaka senaryolarının gerçekleşmesi durumunda çalışanların ölüm ve uzuv kaybı gibi sonuçlarla karşılaşma olasılığı bulunmaktadır. Proseslere göre 4 kümede toplanan vaka senaryoları için en düşük risk ortalamaları yemekhane ve soyunma odalarıdır.

***Anahtar Kelimeler –** Alabalık çiftliği, iş sağlığı ve güvenliği, risk değerlendirmesi, su ürünleri yetiştiriciliği*

Occupational Health and Safety Risk Analysis in Trout Aquaculture Facilities

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Abstract − The aquaculture sector, which responds to alternative food supply, continues to grow exponentially with each passing day. For this reason, there is a need for manpower to meet the increasing workload in aquaculture facilities. As in every sector, occupational health and safety is quite important for employees in aquaculture. The current study focused on case scenarios that may occur in an integrated trout farming facility. Expert opinions for a total of 79 different case scenarios were evaluated. The case scenarios analyzed with the 5x5 matrix method showed that high-risk cases can occur in the facility-wide, culture tanks, toilets and feed storage. The highest number of risks for all case scenarios is in the medium risk category. In the medium risk category, there is a potential for employees to encounter consequences such as death and loss of limbs, especially if the case scenarios foreseen for the facility are realized. The lowest risk averages for case scenarios collected in 4 clusters according to processes are dining hall and locker rooms.

***Keywords −**Aquaculture, occupational health and safety, risk assessment, trout farming*

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1. Introduction

In order to cope with the animal protein needs of the increasing world population in the future, it is necessary to increase the production of fisheries in sea and inland waters (Ahmed et al., 2019; Aydoğan, 2020; Gutierrez-Wing and Malone, 2006; Matos et al., 2006). Aquaculture, which is the fastest growing animal production sector in the world, has become an indispensable part of the food supply today (FAO, 2018). The ongoing situation in aquaculture production shows that capture production is more than aquaculture. In equalizing this difference, the increasing awareness of people for aquaculture in parallel with the decrease in the stocks in water resources plays an important role. World Bank (2013) predicted that capture production will steady at approximately 93 million tons in the 2010-2030 period. Aquaculture needs to reach 140 million tons in 2050 in order to provide the desired fishery production (Waite et al., 2014). Therefore, interest of investors in aquaculture facilities will increase even more throughout the world.

The growth potential of the aquaculture sector in the future will draw attention to the need for a workplace safety for the personnel working in the facilities. The International Labor Organization reported that 1.2 million employees die each year due to lack of occupational health and safety. In addition, more than 160 million employees get sick every year due to unsafe work environments (Tadesse and Admassu, 2006). In 2005, the number of personnel working in the aquaculture sector was 23.4 million directly and indirectly (Valderrama et al., 2010). This number reached 59.5 million personnel in 2018 (FAO, 2020). Intensive levels of production and processing in seafood have, and continue to cause, more frequent reporting of occupational health problems among employees in the sector. Working around aquatic environment poses a special danger, and working alone at night increases the danger (Melvin L. Myers and Durborow, 2012).

According to global statistics, while 1 employee dies in every 15 seconds due to work accidents and occupational diseases in the world, 160 employees are exposed to work-related accidents (Mert and Ercan, 2014). Annual data show that more than 2.3 million employees die due to work accidents and occupational diseases, and more than 317 million occupational accidents were experienced (Kılkıs, 2013). For instance, the mortality rate of employees in the aquaculture industry in Norway is approximately 17 times higher than in other industries (McGuinness et al., 2013). In the United States, the non-fatal occupational injury rate for inland aquaculture in 2006 was reported as 6.8 injuries per 100 full-time employees (Cole et al., 2009; Myers, 2011). In Brazil, a total of 873 people were injured or had occupational diseases between 2013-2017 (Cavalli et al., 2020). Job design, physical, chemical, biological and psychosocial hazards cause most of the possible accidents in the aquaculture industry (Moreau and Neis, 2009). In specific to trout facilities, the factors that will adversely affect the working life are high pressure water jets, working in narrow areas, drowning, fires, unprotected saws and slips and falls due to the lack of raceway edges (Ngajilo and Jeebhay, 2019). Employees in aquaculture industry are more vulnerable to occupational injuries and diseases due to inadequate health and safety management strategies (Marques et al., 2020). It is very important to determine the dangers beforehand and to take precautions against them in order to decrease the work accidents. In this study, occupational health and safety risk analysis was carried out considering the case scenarios that may occur in trout facilities.

2. Methods

2. 1. Probable trout facility

The current study focuses on the trout farms that produce the mostly inland fish farming in Turkey. Risks that may adversely affect occupational health that may occur in this sector, where raceway pools are generally used for inland aquaculture, have been taken into consideration. Trout facilities can be a complex structure from hatcheries to brood fish ponds, as well as small facilities that can be sold by purchasing juvenile fish and transporting them to the market size. In this study, risk factors that may occur in a full-scale trout farm were evaluated general and for each process. The processes anticipated to be found in the trout facility; broodstock tanks, hatchery, fingerling tanks, culture tanks, feed storage, dining hall, toilet and locker rooms. In addition, risks that may occur throughout the facility have been evaluated. Thus, trout farms in any scale will be able to receive support from the current study.

2. 2. L type matrix and expert qualification

The 5x5 matrix diagram (L Type Matrix) is a simple method used to evaluate the relationship between likelihood and consequence and can be applied by a single expert. The 5x5 L-type decision matrix is an ideal scale for analysts who often perform individual risk analysis. In addition, it can be used in many fields with its easy applicability (Özgür, 2021). A total of 79 case scenarios were examined throughout the study. In each case scenario, likelihood and consequence likert scale ranging from 1-5 were used. Expert opinion was obtained from six specialists for likelihood and consequence values of each case scenario. While defining the case scenarios, experts presented risk and prevention advice individually for each process. Afterwards, all scenarios were collected and selected by each expert, and the final case scenario table was created. All individuals in the expert group are educated in aquaculture. In addition, there are trout aquaculture owner, occupational health and safety expert, inland fish farming personnel and academicians among the experts. For the 5x5 risk analysis method, the risk assessment score (RAS) of each case is calculated according to Equation 1. Risk groups related to RAS and likelihood-consequence scale (Güner, 2018) are shown in Table 1. In RAS calculation, the probability of occurrence about a case scenario is determined based on expert opinion and then the effect of the probability is determined in realization case. If the RAS is between 1-6, the low risk (LR) is classified as "The risk that will endanger the occupational health and safety in the current case is low, the risk can be reduced with protective equipment and training". With the RAS taking a value between 8-12, case scenario is middle risk (MR) and it is classified as "Safety measures should be taken and these measures should be applied as soon as possible". Finally, if the RAS value is between 15-25, the high risk (HR) class is taken into consideration, "Safety measures must be taken urgently, work must be stopped until adequate control measures are provided, people must be kept away and management must be informed".

$$RAS = \text{likelihood} \times \text{consequences} \quad \text{(eq. 1)}$$

Table 1. RAS, Likelihood and Consequences Scale

RAS			Likelihood				
	Description		Rare	Less likely	Possible	High probability	Certain
		Scale	1	2	3	4	5
Consequences	No injury	1	1 (LR)	2 (LR)	3 (LR)	4 (LR)	5 (LR)
	Short-term injury	2	2 (LR)	4 (LR)	6 (LR)	8 (MR)	10 (MR)
	Prolonged injury	3	3 (LR)	6 (LR)	9 (MR)	12 (MR)	15 (HR)
	Lifetime effect	4	4 (LR)	8 (MR)	12 (MR)	16 (HR)	20 (HR)
	Death	5	5 (LR)	10 (MR)	15 (HR)	20 (HR)	25 (HR)

2. 3. Statistical analysis

In the current study, RASs of case scenarios considered for each process are given with mean and standard deviations. ANOVA and Tukey tests were used while evaluating RAS values between groups according to processes. In addition, crosstab and chi-square analysis were made between risk groups and processes. Finally, the similarity analysis of the processes in terms of risk score averages was evaluated using the Euclidean distance method. Similarities and distances are visualized with dendrogram graphs. All statistical analysis were performed by SPSS 22.

3. Results and Discussion

Risk analysis scenarios for trout facilities were prepared by taking into account similar studies before. Expert opinions were obtained from facility and academic staff on the evaluation of risk analysis. Thus, case scenarios that would pose risks within the facility were examined by both field personnel and expert academics. Case scenarios have been prepared by considering physical, chemical and biological factors in all processes within the facility (Mert and Ercan, 2014). 79 case scenarios evaluated by experts were individually shown in Supplementary Material (SM1). Prevention advices for all case scenarios that have occurred and have the potential to occur in a full-scale trout farm are presented in SM1. Case scenarios were analyzed based on the 5x5 risk matrix method. According to the general risk assessment results, six different case scenarios draw attention in the HR group.

These are (S17) wet/slippery ground in broodstock culture environment, (S30) transportation of heavy feed sacks with manpower, (S52) absence of insulating mat in front of the electrical panel, (S57) emergency squads not determined according to hazard class of workplace, (S62) long time working and, (S79) absence of electrical warning signs. It is the sole responsibility of the business to reduce or eliminate risks for the HR group. The recommendations to reduce the risk scenarios in HR groups are as follows: (S17) employees must wear slip-resistant boots, (S30) forklifts should be used for loads above the maximum weight for men and women, (S52) a full insulating mat with a width of at least 50 cm must be kept in front of the electrical panels and constantly checked, (S57) the necessary training should be given to the emergency squads according to the hazard class of the workplace, (S62) Employees are required to undergo eye examination periodically (at least once a year) and, (79) there should be occupational health and safety signs on the electrical panels. In the overall risk assessment of the facility, 47 and 26 case scenarios were considered for MR and LR group, respectively. Accordingly, the ratios of case scenario risk number for LR, MR and HR are 33%, 59% and 8%, respectively. Although the highest risk numbers were in the MR group, it was observed that the likelihood score of the risks in the HR group were low and the consequences score were high, especially for the facility in general. In case of case scenarios in MR groups, results such as death or loss of limb on employees may occur. The likelihood scores are higher for case scenarios in other fields of activity. This situation shows that the risks will be quite low if precautions are taken for the relevant case scenarios.

The number of case scenarios for different processes is the minimum in the fingerling tanks (P14-16) and toilets (P42-44), and the maximum in the facility-wide (P50-79). Case scenarios of hygiene rules have been determined in toilets and these risks are generally caused by microbiological activities. The risk from fish grading in fingerling tank is process specific and has a low potential to occur. The risks in facility-wide can come across in many different sectors. These risks include several hazards that affect vital to employees. In this study, the lack of the most basic occupational health and safety activities in an integrated aquaculture facility was taken into consideration. There are also several mutual case scenarios in the processes such as S1, S7, S16 and, S17. However, the same case scenarios have the potential to occur differently in each process. Therefore, same case scenarios in the study have not been evaluated collectively for the facility-wide. For instance, RAS from falling has low risk in fingerling tanks (S16), while it has drowning risk depending on water depth in broodstock tanks (S1). The mean RAS for each process was compared and significant differences were observed between the groups ($p<0.01$). As shown in Figure 1, values of RAS in the dining hall and locker room were found to be significantly lower than in the culture tank, feed storage, toilet and facility-wide. Results of case scenarios in dining hall can cause diseases such as food poisoning, stomach disorders which affect short-term in employees. Therefore, the low consequences score reduced RAS value in dining hall. Similarly, the RAS score is low, as consequence scores in the locker room are considered as short-term discomfort.

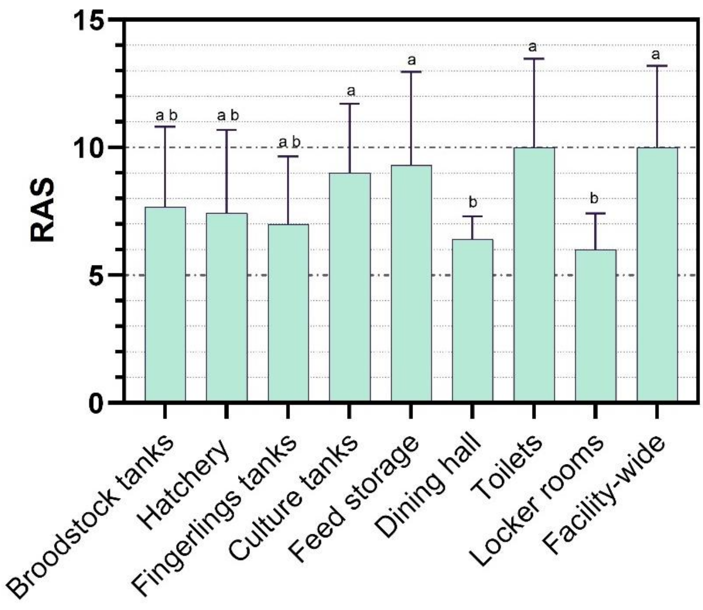

Figure 1. Average RAS Values for Each Process

Cross tabulation for risk groups and processes is shown in Table 2. While the LR group has the highest rate for the locker room and the dining hall, the MR group has the highest rate for all other processes. In addition, a total of 6 case scenarios were observed for the HR group, and 4 of them represent facility-wide risks. According to the dendrogram graph, 8 processes are gathered in 4 clusters (Figure 2). While the toilets (A1) form a single cluster, the other clusters are the dining hall, locker rooms and fingerling tanks (A2), broodstock tanks and hatchery (A3), and feed storage and culture ranks (A4). The processes in cluster A4 with the highest scores and in cluster A2 with the lowest scores have individually high similarity compared than others. The A1 cluster, which includes only one process, formed a single cluster since the average risk score was quite high, although there were 3 case scenarios. Culture tank, feed storage and toilets are priority in terms of occupational health and safety and improvements in these areas should be planned to reduce RAS levels.

Table 2. Cross Tab for Processes and RAS Categories

			RAS Category			
			LR	MR	HR	Total
Process	Broodstock tanks	Count	2	4	0	6
		% within Process	33,3%	66,7%	0,0%	100,0%
		% within RAS Category	7,7%	8,5%	0,0%	7,6%
	Hatchery	Count	3	4	0	7
		% within Process	42,9%	57,1%	0,0%	100,0%
		% within RAS Category	11,5%	8,5%	0,0%	8,9%
	Fingerling tanks	Count	1	2	0	3
		% within Process	33,3%	66,7%	0,0%	100,0%
		% within RAS Category	3,8%	4,3%	0,0%	3,8%
	Culture tanks	Count	2	7	1	10
		% within Process	20,0%	70,0%	10,0%	100,0%
		% within RAS Category	7,7%	14,9%	16,7%	12,7%
	Feed storage	Count	3	6	1	10
		% within Process	30,0%	60,0%	10,0%	100,0%
		% within RAS Category	11,5%	12,8%	16,7%	12,7%
	Dining hall	Count	4	1	0	5
		% within Process	80,0%	20,0%	0,0%	100,0%
		% within RAS Category	15,4%	2,1%	0,0%	6,3%
	Toilets	Count	1	2	0	3
		% within Process	33,3%	66,7%	0,0%	100,0%
		% within RAS Category	3,8%	4,3%	0,0%	3,8%
	Locker rooms	Count	4	1	0	5
		% within Process	80,0%	20,0%	0,0%	100,0%
		% within RAS Category	15,4%	2,1%	0,0%	6,3%
	Facility-wide	Count	6	20	4	30
		% within Process	20,0%	66,7%	13,3%	100,0%
		% within RAS Category	23,1%	42,6%	66,7%	38,0%
Total		Count	26	47	6	79
		% within Process	32,9%	59,5%	7,6%	100,0%
		% within RAS Category	100,0%	100,0%	100,0%	100,0%

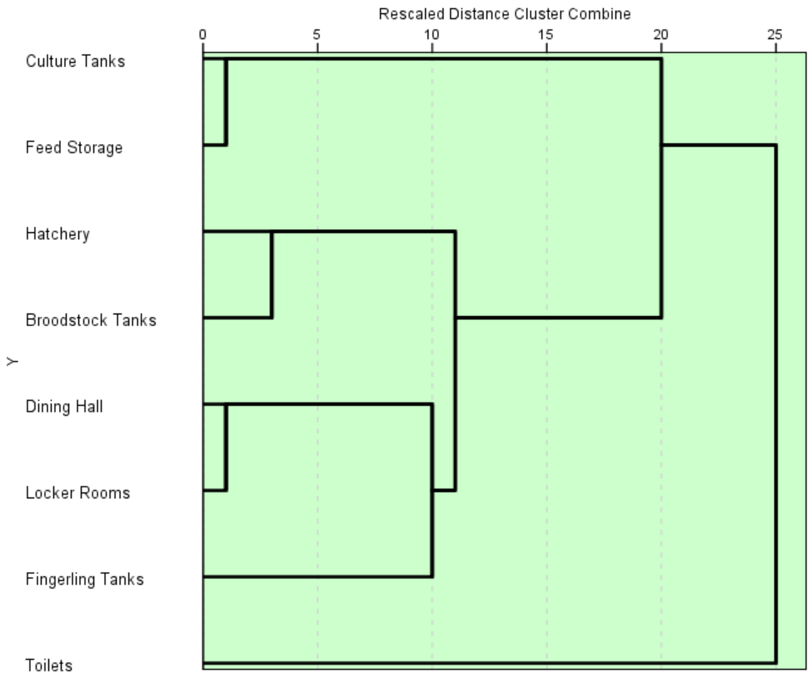

Figure 2. Grouping the Evaluation Criteria by Euclidean Distance Method

4. Conclusions

Aquaculture has become an important sector that will respond to the alternative food supply due to the increasing population around the world. As in every sector, the occupational health and safety in aquaculture facilities is quite important for employees. Therefore, the current study focused on the trout facilities that produce the most as aquaculture in Turkey. A total of 79 different case scenarios were determined that could occur in a fully integrated potential raceway trout facility. Case scenarios were evaluated by both facility employees and academics in accordance with the 5x5 matrix method. 6 different case scenarios included in the high-risk group were observed. While 4 of these are risks that may occur in the facility-wide, others may occur in feed storage and culture tanks. Case scenarios in the high-risk group have a death risk and is quite important for occupational health and safety. Therefore, it is recommended that facilities take their occupational health and safety planning seriously, taking into account high-risk scenarios. Case scenarios in feed storage, toilets and culture tanks are risks that facilities should take precautions, except of the facility-wide. According to the cross-tabulation and dendrogram graph, the similarities of the risks in the facilities were examined and the culture tanks and feed storage with higher risk score averages and risk numbers compared to other groups were determined as processes with hazard potential. This study will be a guide for aquaculture as it includes the risks that may occur in trout culture facilities around the world.

Download Link for Supplementary Material (SM1): https://dergipark.org.tr/tr/journal/2681/file-manager/24633/download

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Conflict of Interest / Çıkar Çatışması

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No conflict of interest was declared by the authors.