Antibiotic Applications in Fish Farms and Environmental Problems

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Abstract
Today, fish farming creates significant impacts on water resources and food chain from a global perspective, as compared to those of the other agricultural activities. Some methods and chemicals heavily using production and consumption periods in fish farming are related to the environmental damages. Chemicals have a common usage in both the world and our country to protect the products from the negative effects of diseases. They are also imposed to increase the production. As Turkey has significant potential in fish farming in comparison to many other countries in the world, there is a wide use of antibiotics in production. This research examines the use of antibiotics in fish farming to shed light on the effects of chemicals on the production and human health.

Keywords: Antibiotic, Fish Farming, Environmental Factor, Aquaculture
1. INTRODUCTION

Environmental pollution is defined as the deterioration of the natural balance of the ecosystem by various pollutants emerging as a result of human activities (Karaman, 2006). Therefore, in order to be able to eradicate the pollution, scientific studies are being carried out at the international level (Orçun and Sunlu, 2007). Scientific studies on this issue investigate the imbalance related to the ecology in different ways and suggest solutions (Karaman, 2006). In particular, fish farms need to be monitored in terms of unconscious and irregular chemical usage (drugs and antibiotics, disinfectants etc.) and in parallel with this, in terms of formation of environmental pollution. Antibiotics are substances produced by microorganisms that can destroy the growth of other microorganisms. At the present time, antibiotics are not only used as a drug for humans. It is also broadly used in livestock breeding and fish farming. Some of the microorganisms that cause health problems in fish farms include Mycobacterium marinum, Nocardia spp., Edwardsiella tarda, Vibrio vulnificus, Vibrio parahaemolyticus, Streptococcus iniae, Lactococcus garviae, Micrococcus lylae, Aeromonas hydrophila, Plesiomonas shigelloides, Erysipelotrix insidiosa, Escherichia coli, Salmonella spp., Raoultella ornithinolytica, Pseudomonas spp., Leptospira interrogans, Yersinia ruckerii and Stenotrophomonas maltophilia (Türk, 2015). Antibiotics used for health and development in fish farms can kill beneficial microorganisms in the receiving environment. In addition, the application of antibiotics in fish farms leads to the proliferation of antibiotic-resistant microorganisms. It is generally known that 20-30% of antibiotics are in the body of fish, and the remaining 70-80% are transmitted to the environment. However, antibiotics that are recklessly discharged into the medium pose a major danger to habitats and all living things (Zhong et al., 2018; Uma and Rebecca, 2018; Yang et al., 2018; Li et al., 2018; Tran et al., 2016; Martinez et al., 2015; Bengtsson-Palme and Larsson, 2015; Van Boeckel et al., 2015). Anthropogenic activities result in the input of different antibiotics into aquatic environments, including effluent from hospitals and wastewater treatment facilities and discharge from agriculture, fish farming, and livestock husbandry (see Fig. 1) (Yang et al., 2018; Guo et al., 2017; Mishra et al., 2017). Today, some factors such as the rapid increase of food demand in parallel with the increasing population, socio-economic progress and the efforts to reach healthy food led to the numerical development of fish and similar species having economic values (Meador et al., 2016; Scott et al., 2015).

Aquaculture is an effective food production area in terms of reducing the unconscious fishing in the natural fishery, creating business space and supporting the economy. Aquaculture has become an important food source with the increase of the global population (Miranda et al., 2018). Fish farming industries play a crucial role in profit and employment in worldwide and procuration reliable foods to the population of the countries (Rahman et al., 2017). The value of fish produced in fish farms has increased steadily in the last four decades (see Fig. 2) (Elevancini, 2017). For these reasons, aquaculture tends to increasingly grow all over the world and in Turkey. Compared to other countries, aquaculture activities in fish farms in Turkey are quite new (see Table 1) (Aydm and Baltaci, 2017; Özdal and Pulatsü, 2012).

Fig. 1. Spread of antibiotics in different environments and possible exposure to all live health (Yang et al., 2017a; Yang et al., 2017b). (A: antibiotics from wastewater treatment facilities-hospitals; B: antibiotics from agriculture, aquaculture and livestock husbandry; C: drinking water; D: recreation and swimming; E: swallow of aquatic products; ① the precipitation of antibiotics from water; ② the resuspension of antibiotics from residue; ③ change of microbial community by antibiotics; ④ chemical drugs cumulative by the aquatic medium; ⑤ antibiotics released from the death of aquatic lives; ⑥ Antibiotics absorbed/adsorbed by water biota; ⑦ the transport of antibiotics and drugs among aquatic biota)
Tablo 1. According to the year in Turkey, the amount of product produced in fish farms (Kayhan and Olmez, 2014).

| Fish species      | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Total (tonnes)    | 138773| 151990| 158640| 166801| 188785| 212410| 233394| 233713| 238638| 250281|

**Fish farms in the inland water district**

| Fish species       | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|--------------------|------|------|------|------|------|------|------|------|------|------|
| Trout (Rainbow)    | 58433| 65928| 75657| 78165| 100239| 111335| 122873| 107533| 100411| 99712 |
| Mirror-carp        | 600  | 629  | 591  | 403  | 207  | 222  | 146  | 157  | 206  | 196  |
| Sturgeon           | -    | -    | -    | -    | -    | -    | 17   | 28   | 6    |      |
| Tilapia            | -    | -    | -    | -    | -    | -    | -    | 32   | 12   | 58   |

**Fish farms in the sea area**

| Fish species       | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|--------------------|------|------|------|------|------|------|------|------|------|------|
| Trout (Rainbow)    | 2470 | 2721 | 5229 | 7079 | 7697 | 3234 | 5186 | 4812 | 6187 | 4643 |
| gill-head bream    | 33500| 31670| 28362| 28157| 32187| 30743| 35701| 41873| 51844| 58254|
| Perch              | 41900| 49270| 46554| 50796| 47013| 65512| 67913| 74653| 75164| 80847|
| Fangri             | -    | -    | -    | -    | -    | -    | 106  | 143  | 225  |      |
| Granözyz           | -    | -    | -    | -    | -    | -    | 3281 | 2801 | 2463 |      |
| Tunny              | -    | -    | -    | -    | -    | -    | -    | 113  | 132  | 43   |
| Other              | 1600 | 1772 | 2247 | 2201 | 1442 | 1364 | 1575 | -    | -    | -    |

**Fig. 2.** Global production and value of cultured fish for the period 1984-2015 (Elevancini, 2017).

Due to the faces and non-consumed feed, food elements in various forms (organic carbon, nitrogen, phosphorus) enter the receiving environments in the fish farms (Topçu et al., 2017; Yavuzcan et al., 2010). In addition, the antibiotic and drug residues used to protect fish and aquatic products from diseases also enter the receiving environments (Agoba et al., 2017; Kim et al., 2017; Caruso, 2016; Meador et al., 2016; Scott et al., 2015;). These chemicals accumulating in the base of the cage systems of these farms cause adverse changes in the life on the seabed, and therefore, they form sensitive areas in terms of environmental pollution. The production-environment interaction needs to be evaluated in order to determine whether the aquaculture in net cages used in the fish farms cause pollution of water resources. Fig. 3 shows the components that should be in a cage system used in these farms. The environmental problems occurring in fish farms during the aquaculture works are graphically expressed.

In this study, the environmental effects of production of various fish and other aquatic products carried out in cage systems in fish farms on especially water ecosystem, sediment, benthic flora and fauna, the harmful aspects of antibiotics and other drugs used to destroy pathogenic microorganisms and the problems that might occur in the food chain were investigated.

**Fig. 3.** Main inputs (straight lines) and output (cut lines) from cages in fish farms (URL-1, 2018).

2. MATERIAL AND METHOD

All academic areas related to fish farms and antibiotic usage were determined by electronic scanning of MEDLINE, PubMed, Google academic, ISIWeb of Science, Springer, Taylor-Francis, Elsevier and Scopus without time and language limitations. By using some keywords (fish farms, antibiotics, environmental problems, feed, cage fishing etc.), a national and international literature review was carried out.

3. ENVIRONMENTAL EFFECTS OF FISH FARMS

Although the rapid development of fish farms provides important socio-economic contributions to the countries, particularly their negative effects on water quality and ecological structure arise concern. Depending on the production methods and technologies in the farms, the amount of water products produced, and the quality of the receiving water environment, the size of this environmental change on the ecosystem varies.
3.1. Solid wastes and antibiotics

The negative effect of fish farming in cages on water resources emerges mainly due to the wastes originating from the aquaculture (Meador et al., 2016; Abu Bakar et al., 2016; Scott et al., 2015). The types of waste originating from farms established in the receiving water environment have similar features all over the world, and the characteristics and levels of waste differ only according to the type of aquatic products and the farming technique (Yayan, 2015). Pollutants occurring as a result of the production of aquatic products in fish farms are considered as two different groups. The majority of solid wastes originating from fish farming is composed of substances such as fish faeces, scales, mucus secretion and non-consumed feed (see Fig. 4).

Fig. 4. Contaminants originating from a fish species produced in fish farms (Yayan, 2015; Rein et al., 2015).

The highest rate of environmental pollutants in fish farms belongs to the pollutants resulting from feeding. At this point, it is observed that in the farms where proper feeding is not applied, there is a sediment accumulation and therefore an increase in the organic load of water (Yayan, 2015; Rein et al., 2015; Yeo et al., 2004; Bureau et al., 2003). Solid wastes that are exposed in fish farms negatively affect the physicochemical structure and biological equilibrium of the different waters (Kim et al., 2018; Opioyo et al., 2018; Schumann et al., 2017; Dolan et al., 2013; Mirzoyan et al., 2010). These solid wastes consist of various antibiotics, medicines, and uneaten fish food mixed with disinfectant, faeces, dead fish excretion and bio-flora. In particular, Tetracycline and amoxicillin are intensively applied with the aim of protecting the health of the fish (Chen et al., 2017). Continuous exposure to these antibiotics in aquaculture may increase high antibiotic resistance (Zhao et al., 2017; Harnisz et al., 2015; Di Cesare et al., 2013). Studies have reported that solid waste from fish farmings can act as potential pollutant-containing antibiotics (Kim et al., 2018; Chen et al., 2018; Xiong et al., 2015; Luo et al., 2010).

Antibiotics, drugs and hormones are extensively used in fish farms in order to treat the diseases caused by microorganisms such as Clostridium, Vibrio, Pseudomonas, Escherichia, and Salmonella, to enhance resistance, to improve product quality and for the other purposes (Cengizler et al., 2017; Türk and Öğuz, 2013; Neary et al., 2008.). In particular, various behavioural changes observed in fish (period movement, drowsiness, gathering together, etc.) and changes in the appearance of the eye (eye bleeding, colour problem, swelling, cysts, etc.) increase the use of these chemicals intensively. Especially, some antibiotics are used in the fish farms in all regions of the world (see Table 2) (Baba, 2017; Türk and Öğuz, 2013). In fish farms, sodium, baylucite, iodophors, oxytetracycline, amoxicillin, erythromycin, sulphonamides are widely used both in the world and in our country.

Table 2. Some chemicals used in fish farms (Kumar and Roy, 2017).

| Antibiotics       | Other Drugs     | Disinfectants     |
|-------------------|-----------------|-------------------|
| Florfenicol       | Akinitrazol     | Phenols           |
| Bacitracin        | Methyl Parathion| Zephril           |
| Chloramphenicol   | Salicyclic acid | Sodium            |
| Enrofloxacin      | Copper sulphate | Baylucit          |
| Canamycin         | Trypaflavin     | Formalin          |
| Erythromycin      | Rivanol         | Chloramine T      |
| Griseofulvin      | Piavetrin       | Slaked lime       |
| Oleandomycin      | Niclosamid      | Quicklime         |
| Neomycin          | Metrifonate     | Iodophors         |
| Oxytetracycline   | Lysol           | Gonadotropin      |
| Polymyxin         | Gabrocol        | Ormetoprim        |
| Sulfamerazine     | Diflubenzuron   | Sulfasol          |
| Sulfanilamide     | Malathion       |                   |

3.2. Effects on water quality criteria

In the cage where fish and other aqueous products are kept at fish farms, the effects of wastes originating from different production on aqueous environment have been being frequently observed in recent years. In particular, some studies have found that nitrogen, phosphorus, organic substance, chlorophyll-a, antibiotic residues, trace elements and suspended solids in the aqueous ecosystem increase the amount of solids, and reduce the entry of sunlight into the water, oxygen levels and acid-base balance. When the organic substance entering the aqueous environment by feed dissolves in water or transfers from sediment to water, it can lead to eutrophication and reduce the permeability of light especially in the environments where nutrients are limiter (see Fig. 5) (Coldebellia et al., 2018; Abu Bakar et al., 2016; Mancuso, 2015; Kayhan and Ölmze, 2014; Koca et al., 2011; Holmer, 2010; Yıldırım and Korkut, 2004).

4. CONCLUSIONS

While the world population is growing rapidly, humans’ need for food, especially the need for animal source food is also increasing. In line with this food demand, fish farms have become one of the rapidly growing food sectors on the global scale. Together with the development of the aquaculture field, the increase of pollution problems in the ecosystem has become inevitable. Because of the chemicals used in this sector such as antibiotics, hormones, and drugs, important environmental problems have been observed in terms of the quality of receiving water, sediment and benthic ecosystem. As in the entire in pollution situation, a
strategy and plan for the pollution related to the fish farms also need to be developed. During the establishing and operating the fish farms, keeping certain precautions and rules in the foreground is of great importance to minimize the environmental pollution. In this context, the environmental aspects of aquaculture can be assessed in all aspects in the light of the following items.

1. In the selection of the area where the farms will be established, places with high flow rates should be preferred instead of places with low flow rates.
2. In the appropriate areas, at the end of each production season, the location of the cages should be changed; that is, the rotation should be applied.
3. In fish farms, feed management must be provided separately for each aquatic product and in this way, solid waste control must be ensured.
4. Because of some conditions (temperature-flow rate changes, insufficient gap rates in cages, water quality parameters) that can be observed in the areas established in fish farms, there may be uneasiness and restless behaviors in fish and similar aquatic products. In order to eliminate the existing stress, the regular control of the cage systems should be ensured.
5. Environmental monitoring of fish farms should be performed. In this way, detection of the problems arising from the farm and intervention to the problems are realized in a shorter time.
6. The natural landscape in the facility usage area should be given importance; especially endangered species of plants should not be harmed. Legislation, regulations, standards, and practices covering long years for such production in the country should be carried out and implemented in conjunction with both the production authorities and the population living in the region. In addition, activities that can eliminate environmental problems arising from fish farms should be concentrated on.

![Diagram](https://example.com/diagram.png)

**Fig. 5.** Discharges and changes in the water environment of organic charges (Coldebella et al., 2018; Jakobsen et al., 2017; Abu Bakar et al., 2016; Buschmann et al., 2009).
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