The Environmental Impacts of Fish Cages on Water Quality in Rosetta Branch

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ABSTRACT
Water is the source of life to human, plants, animals and aquatic life. The main water supply in Egypt is River Nile and it undergoes many types of pollution one of them is Fish cages. This work studies the impacts of fish cages on freshwater quality of WTPs intakes located in Rosetta branch from River Nile and the environmental risks associated with it. Water samples were collected in June 2015 and December 2015 from WTPs located in Rosetta branch and additional samples upstream from fish cages. Ammonia levels increased from 0.16 ppm into 2.2 ppm due to mixing with the agriculture drains and increased significantly up to 14.2 ppm due to fish cages causing deterioration of water quality. The dissolved oxygen decreased as a result of ammonia elevation coming from fish cages. Depleted oxygen caused death of fish. COD and BOD should be less than 10 and 6 ppm respectively according to fresh water national standards. The results showed exceeded values of COD and BOD due to the presence of biodegradable substances, which consume oxygen. Finally, urgent actions should be taken from the concerned authorities. Actions should include awareness of the necessity of protecting the River Nile and call the sacredness of Nile from the historical legacy at Egyptian citizens. As officials should remove the fish cages to implement the law and to deter offenders and fined. It is possible to apply unconventional technologies to deal with the current state till improving the situation.

Keywords: Water quality, fish cages, River Nile, Rosetta branch, ammonia, environmental risks

Introduction
Egypt, a major country is facing a lot of challenges as a result of the high rate of population growth, and may be the food one of these challenges. Certainly, fish is one of alternatives as a source of protein. Therefore, fish culture is an important activity to provide food and protein. Also, it provides job opportunities and a resource of financial income whether at person level or nation level (Zaghloul and Elwan, 2011).

The concern over the environmental impacts associated with the fish farming urged the state to enact laws governing fishing and aquaculture ended with Law No. 124 of 1983. This Law organizes fishing, fish farming in Egypt. It authorizes the General Authority for Fish Resources Development of the Ministry of Agriculture, as the responsible organization for the implementation of this law which prohibits the use of Nile water in fish farming. Also, it identifies non-arable areas for this purpose using the brackish water or treated sanitation (FAO, 2005).

Fish farming in floating cages has been established in Nile River branches illegally because it is simple technology, does not require additional water and economically feasible. The benefits of such activity include increases in farm productivity and profitability without any net increase in water consumption (Ali et al., 2006). In 2005, Municipal authorities announced that Damietta governorate
cleanse Damietta branch from fish cages while on the other side they cannot do a similar action in Rosetta branch, which suffered from pollution (Al Akbar, 2005) fish farmers find several ways to hide the cages by submersion under the water.

Rosetta branch represents the main freshwater stream that extends northwards for about 256 km on the western boundary of the Nile Delta from Egypt’s Delta Barrage. Rosetta branch has an average width of about 180 meters and a depth ranges 2-4 meters. It ends at Edfina Barrage, located at 30 kilometers south of the sea to discharge of excess water to the Mediterranean. Rosetta branch is a source of fresh water for domestic, agriculture, industry, fisheries and tourism purposes for Giza, Monofia, Gharbia, Kafr el Sheikh and Behaira governorates in western Delta of Egypt. Unfortunately this branch is impacted by pollution resulted from the agricultural drains located along its sides which included the industrial effluents of industrial activities and fish farming cages. (El Gammal and El Shazely, 2008)

In Egypt, Law No. 27/1978 regulates public resources for potable water and human use and makes the task entrusted by the Ministry of Housing, Utilities and Urban Development. Decree No. 458/2007 issued from Ministry of Health determines specifications for drinking water pursuant to the provisions of this Law. WTPs in governorates of Gharbiya, Kafr el Sheikh and Beheira face challenges and difficulties to produce drinking water matching with healthy specifications in compliance with decree 458/2007, while utilities of drinking water in governorates of Menoufia and Giza avoid the use of Rosetta Branch as a source of drinking water plants. (Abdelmawla et al., 2016)

A fish cage contains large quantities of fish which need respiration. Thus, it depletes dissolved oxygen and makes DO under natural limits for freshwaters in rivers. As well as fish excretion and faeces production from feeding increases the concentrations of organic and inorganic nitrogen N (figure 1), phosphorus, total carbon, biological oxygen demand (BOD) and organic matter. Such conditions lead to pollution and deterioration of the ecosystem of rivers and all of this is most dangerous with bad type of feeding. The use of chemicals and the introduction of pathogens have also raised environmental concerns. Environmental impacts of fish farming depends very much on species, farming method, quantities density, feed type and hydrograph of the water body (Wu, 1995 and Beveridge, 1985).

![Fish Waste](image)

**Fig. 1:** Nitrogen cycle in water

Fish Cages in Egypt are usually made of a rigid frame as shown in figure 2 and are usually covered with a mesh material through which water can readily flow but fish cannot escape. Most of the feed used is in mash form for poultry, cattle, sheep, fish, etc. It worth mentioning that less than 3% of the high quality feed production is through licensed private sector factories, while the rest is not under monitoring and lacks quality control program (El-Gamal, 2011).
Fig. 2: Fish cages in Rosetta branch

In ecosystem of waterways lives different kinds of fish as free and it be component from system. Thus, the input and output be assimilated by surrounding environment. All the values of chemical parameters in the locations of floating fish cages in the Rosetta branch were the highest when compared to the free-fish locations. (Ali et al., 2006).

This paper address the impact of fish cages on freshwater quality of WTPs intakes located in Rosetta branch from Nile River and to help the decision maker to recognize the necessity to enforce the Law and remove fish cages from waterways.

Materials and Methods

1. Study Area

Up to 200 km is length from Rosetta branch between Khairiya barrage to the north ending with Edfina barrage which regulating the excess flow of the branch to be released to the Mediterranean Sea.

It is considered as one of the major sources of freshwater for the western side of the Nile Delta, where several WTPs intakes exist on it such as Basune, Shobra-kheit, Mahallet-AbuAli, Keshla, Fowwa, Sanabada, Atf, Menia-elsaied, Edfina and Motobas which supply the adjacent cities with potable water.

Unfortunately, the branch receives considerable discharges of drainage water that are significantly polluted with domestic and industrial pollutants. It is also used as a media for fish farming.

The Monthly flow of water from Khairiya barrage to Rosetta branch, varies from month to month, gradually implemented limitations determined by Ministry of water resources and irrigation, where the maximum flow in June each year was about 680 million cubic meters per month, while the least flow in December each year was about 160 million cubic meters per month, representing a lowest amount of water needs according to requirements of agriculture and called Winter Damming.

2. Sampling Procedure

Water samples were collected in June 2015 and December 2015 from WTPs located in Rosetta branch and additional samples before fish cages. Water samples were collected (at a depth of 50 cm from the surface) in stoppered polyethylene plastic bottles. All samples collected for their physical and chemical examinations were stored in an ice box and delivered immediately to the laboratory for analyses.

3. Materials

The used chemicals were of analytical grade.

4. Analytical Methods

Physical and chemical analyses were carried out according to Standard Methods for Examination of Water and Wastewater. Ammonia was measured by ion selective electrode method, and nitrite and nitrate were carried out by a colorimetric method by spectrophotometer. Field parameters (temperature, pH, dissolved oxygen and total dissolved solids) were measured on-site (APHA, 2005).
Results and Discussion

Samples collected from fresh water in WTPs intakes that have been noted in section 2.1, namely, (Basune, Shobra-kheit, Mahallet-AbuAli, Keshla, Fowwa, Sanabada, Atf, Menia-elsaied, Edfina and Motobas). Also, additional samples were collected as a reference for comparison between the case without fish cages and the case with the cages. A sample was collected from Embaba WTP intake to represent the water quality before Rosetta branch and samples from the villages of Manshat-Soliman, Abeeg and Farastak, as shown in table 1.

The analyzed parameters were: (temperature, pH, total dissolved solids, ammonia, nitrite, nitrate, DO, BOD, COD and Algae). Results are shown in table 2.

Table 1: Sampling points.

| No. | Location                          | Governorate                  |
|-----|-----------------------------------|------------------------------|
| 1   | Embaba WTP intake                 | Geza, West from Nile         |
| 2   | Monshat-soliman village           | Gharbiya, East from Nile     |
| 3   | Abeeg village                     | Gharbiya, East from Nile     |
| 4   | farastak village                  | Gharbiya, East from Nile     |
| 5   | Basune WTP intake                 | Gharbiya, East from Nile     |
| 6   | Shobra-kheit WTP intake           | Behaira, West from Nile      |
| 7   | Mahallet-AbuAli WTP intake        | kafrelsheikh, East from Nile |
| 8   | Keshla WTP intake                 | kafrelsheikh, East from Nile |
| 9   | Fowwa WTP intake                  | kafrelsheikh, East from Nile |
| 10  | Sanabada WTP intake               | Beaira, West from Nile       |
| 11  | Atf WTP intake                    | Beaira, West from Nile       |
| 12  | Menia-elsaied WTP intake          | Beaira, West from Nile       |
| 13  | Edfina WTP intake                 | Beaira, West from Nile       |
| 14  | Motobas WTP intake                | kafrelsheikh, East from Nile |

Table 2: The results of analysis.

| No | Parameter | Temp. °C | pH | TDS ppm | NH₃ ppm | NO₂ ppm | NO₃ ppm | DO ppm | BOD ppm | COD ppm | Algae Unit/ml |
|----|-----------|----------|----|---------|---------|---------|---------|-------|---------|---------|---------------|
|    | Limit     | Ordinary | 7-8.5 | 800     | 0.5     | 2       | More than 5 | 6  | 10       |         |               |
| 1  | June      | 23        | 8.4  | 220     | 0.09    | --      | --       | 8.5  | 2.9     | 4.93    | 7200          |
|    | Dec.      | 17.7      | 8.3  | 216     | 0.16    | 0.036   | 0.32     | 7.8  | 3.3     | 5.61    | 12000         |
| 2  | June      | 22.5      | 8.3  | 244     | 0.5     | 0.2     | 0.39     | 6.5  | 4       | 6.8     | 10000         |
|    | Dec.      | 17.5      | 7.5  | 354     | 2.2     | 0.153   | 0.82     | 5.9  | 4       | 6.8     | 17000         |
| 3  | June      | 21.3      | 8.1  | 250     | 0.52    | 0.31    | 0.4      | 6.8  | 3.9     | 6.63    | 12400        |
|    | Dec.      | 16.6      | 7.4  | 354     | 2.25    | 0.22    | 0.65     | 6.1  | 3.9     | 6.63    | 18000        |
| 4  | June      | 21        | 8.1  | 245     | 0.52    | 0.33    | 0.45     | 7.1  | 3.8     | 6.46    | 12600        |
|    | Dec.      | 16.3      | 7.3  | 353     | 2.26    | 0.19    | 0.62     | 5.1  | 3.8     | 6.46    | 19600        |
| 5  | June      | 21        | 8.1  | 261     | 0.56    | 0.36    | 0.46     | 6.5  | 5.5     | 8.5     | 12000        |
|    | Dec.      | 16.5      | 7.38 | 354     | 2.14    | 0.2     | 0.62     | 4.8  | 5.4     | 9.18    | 19800        |
| 6  | June      | 20.8      | 8.1  | 270     | 0.62    | 0.36    | 0.47     | 6.5  | 5.4     | 8.5     | 10400        |
|    | Dec.      | 16        | 7.39 | 373     | 3.44    | 0.21    | 0.95     | 4.8  | 6.1     | 10.37   | 20000        |
| 7  | June      | 20.8      | 8    | 277     | 0.66    | 0.39    | 0.44     | 6.5  | 6.1     | 10.2    | 10200        |
|    | Dec.      | 16.1      | 7.36 | 467     | 3.52    | 0.18    | 0.85     | 3.7  | 6.1     | 11.6    | 18400        |
| 8  | June      | 21        | 8    | 289     | 0.7     | 0.4     | 0.45     | 6.2  | 6.6     | 10.2    | 9800         |
|    | Dec.      | 16.4      | 7.37 | 467     | 3.54    | 0.14    | 0.84     | 3.9  | 10.9    | 18.53   | 19400        |
| 9  | June      | 19.7      | 7.9  | 314     | 1.8     | 0.4     | 0.39     | 4.9  | 6.7     | 10.2    | 11200        |
|    | Dec.      | 15.9      | 7.29 | 569     | 14.2    | 0.15    | 0.52     | 3.63 | 11.5    | 19.55   | 19800        |
| 10 | June      | 19.7      | 7.9  | 314     | 0.7     | 0.39    | 0.33     | 5.7  | 7.1     | 11.9    | 10000        |
|    | Dec.      | 16        | 7.3  | 470     | 6.3     | 0.16    | 0.51     | 4.05 | 13.7    | 21.95   | 18600        |
| 11 | June      | 19.7      | 8.3  | 316     | 0.8     | 0.4     | 0.33     | 5.7  | 7.7     | 11.9    | 10200        |
|    | Dec.      | 12.9      | 7.5  | 475     | 7.4     | 0.16    | 0.51     | 4.05 | 13.7    | 21.95   | 20000        |
| 12 | June      | 22.7      | 8.1  | 318     | 0.55    | 0.45    | 0.49     | 6.6  | 7.7     | 11.9    | 8600         |
|    | Dec.      | 16.7      | 7.6  | 487     | 3      | 0.45    | 2.03     | 4.2  | 14.1    | 23.9    | 20000        |
| 13 | June      | 22.8      | 8    | 320     | 0.5     | 0.39    | 0.51     | 6.7  | 10.9    | 20.4    | 8800         |
|    | Dec.      | 16.6      | 7.4  | 496     | 2.8     | 0.45    | 2.03     | 4.35 | 18      | 27.5    | 22000        |
| 14 | June      | 20        | 8.1  | 321     | 0.1     | 0.36    | 0.53     | 4.9  | 9       | 10      | 20.4         |
|    | Dec.      | 15.8      | 7.51 | 570     | 5.4     | 0.32    | 1.17     | 4.15 | 19      | 28.5    | 22000        |
Analyses were carried out in June 2015 where largest quantities of fresh water and it in Dec. 2015 where smallest quantities of fresh water to show the difference between the two cases. It was noted that the best conditions in summer season, so that the greatest amount of water and self-purification of waterways increases the opportunity to assimilate pollutants from agricultural drains and cages.

Ammonia, nitrite and nitrate in Dec. 2015 were displayed in figure (3). Sample No. 1 ammonia level in the permissible limit according Low No. 48/1982 for protection Nile River (NH$_3$ should be lower than 0.5 mg/l). Sample No. (2, 3 and 4) ammonia levels increased from 0.16 ppm into 2.2 ppm due to mixing with the agriculture drains.

![Fig. 3: Ammonia, nitrite and nitrate levels in Dec. 2015](image)

The drains are Rahawy, Sabal, Tahreer, Zaweitel Bahr and Tala. While in the other samples ammonia levels increased significantly due to fish cages and the water quality became in the worst case. Ammonia is oxidized biologically to produce nitrite and nitrate under uncontrolled conditions. The presence of ammonia in water consumes higher concentration of chlorine to get free residual chlorine. Also, the chloramines are weak in disinfection process, as well as the increase in the amount of chlorine with organic load possesses high risk forming of harmful substances such as trihalomethanes and haloacetic acids (THMs, HAAs) which increase the potential of cancer. Therefore, removal of ammonia from water is desirable (EPA, 1975). Nitrates and nitrites are promoting the blooms of algae and unionized ammonia is actually toxic depending on temperature and pH (Wu, 1995)

DO in Dec. 2015 were displayed in figure (4). According to Law No. 48/1982 DO should be more than 5 mg/l. Sample No. (1) in Nile River equal 7.8 ppm and indicate good quality of water, while sample No. (2, 3 and 4) impacted by Agriculture drains, but within range (5.9, 6.1 and 5.1 ppm respectively). The other samples that impacted by fish cages decreased under limits because it consumed by ammonia and respiration of fish cages. This caused death of fish and it is environmental crisis.

Fresh water in Rosetta branch impacted significantly by fish cages in TDS. The added chemicals to fish farms such as (therapeutants, vitamins and antifoulants) affect negatively the eco-system of fresh water. See figure (5).

COD and BOD should be less than 10 and 6 ppm respectively according to fresh water national standards. The samples (5-14) showed, results exceeded the reference because increasing biological and organic substances, consume oxygen-degradable and therefore increase in pollution load. See figure (6)
**Fig. 4**: DO level in Dec. 2015

**Fig. 5**: TDS levels in Dec. 2015

**Fig. 6**: COD and BOD levels
Conclusions

Fish cages form a remarkable threat to water quality: Rosetta branch of the Nile River is considered one of the most important water ways in Egypt. WTPs intakes exist in Rosetta branch are facing challenges because they should produce potable water complied with standards.

On the other hand, detailed current and seasonal water quality data were determined and analyzed from the study area of Rosetta branch to exhibit the impacts of fish cages on the water quality. This comprehensive analysis showed a negative impact of the random fish farming activities on water quality. An increase in the impact is also reflected in the vicinity of the existent drinking water treatment plants. However, this impact should be considered by treatment plants staff and urgent actions should be taken by the concerned authorities.

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