International Journal of Engineering Research and General Science Volume 4, Issue 5, September-October, 2016
ISSN 2091-2730

OPTIMIZATION OF RAW WATER INTAKE LEVEL IN A DAM RESERVOIR

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Abstract— Generally surface water is increasingly threatened by the change in the physic-chemical and biological quality. Indeed, since they are always exposed to frequent climate change on the one hand and influenced by the management of the other hand, some processes can be saved especially in Dam retained water such as: thermal stratification and eutrophication which contributes to the decrease of the content of dissolved oxygen or to anoxia and to release iron and manganese.

Thermal stratification result when there is the warming of the surface layers leading to the temperature difference by creating three distinct layers: epilimnion metalimnion and Hypolimnion.

This work aims to study the whole mass of water from the dam holding Bab Louta to optimize the best level of intake that should supply the treatment plant.

The Bab Louta dam, which supplies TAZA city of drinking water, is not immune to these two phenomena. A study was conducted during 2014 on the various layers of the water retained in order to determine the best level of raw water outlet to power the treatment plant.

Keywords— Dam Reservoir, eutrophication, thermal stratification, level of intake, physical and chemical parameters, epilimnion metalimnion and hypolimnion.

INTRODUCTION

Year after year, the lakes and dams are aging, transform and deteriorate. Operators in the field of water are increasingly concerned about the water quality of their lakes and wonder about how it could be changed. Indeed, it's carried out biological and chemical transformations which cause an inhomogeneous mass of water in terms of temperature and dissolved oxygen. These changes are the main causes of the appearance of thermal stratification and eutrophication.

According to the European Commission Nitrates Directive, eutrophication is defined as 'the enrichment of water by nitrogen compounds causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of water concerned [1].

Nixon [2] defines eutrophication succinctly: It's an increase in the rate of supply of organic matter to an ecosystem.

Arguably eutrophication has been in the hearts of several studies and that's what deducted by Jorgensen and Richardson [3] .

A second phenomenon compounds the effects of eutrophication; it's about the thermal stratification of the water masses of the reservoir lakes due to the difference density of water bodies in connection with the temperature, which causes zoning in water: epilimnion, metalimnion and Hypolimnion [4].

The negative effects caused by eutrophication on water treatment process are numerous:

- Increased chlorine demand thus increased risk of THM formation.
- The increase in pH making difficult the coagulation-flocculation process.
- Algae, that manage to resist treatment, cause clogging of rapid sand filters.
- The appearance of bad tastes and odors in water is surely because of the eutrophication.

To overcome these two phenomena, the optimization level of the raw water intake in the dam remains one of the solutions by National Office of Electricity and Water potable.

Many researches have carried out by applying systems analysis techniques to control water quality through reservoir operations.

S. Richard and al [5] has made a follow-up of physic-chemical water quality characteristics at Petit Saut hydroelectric dam.

F. Donald and al [6] has conducted a study about enhancing water quality in hydropower system operations. Mc Cully [7] and Baghel and al [8] have given a lot of interest in the development of water resources dams.

A.Gartet and al [9] has conducted a study on the treatment and management of the risks of pollution on the waters of the Sahla dam in order to find solutions to the problem of the degradation of the quality of these waters.

In this study, we conducted two sampling companies to determine the best level of raw water at Bab louta dam which supplies a water treatment plant.

1. Materials and Methods

1.1. Location of Bab louta dam

Considered as the main resource supplying drinking water the city of Taza and its regions, the DAM Bab louta was built on Wadi Bou Sbâa, (upstream of Oued Bou Hellou) is located approximately 40 km as the crow flies south west the city of Taza. Its coordinates are: Latitude: 34° 00' 36" N ; Longitude: 42° 21' 00" W

Figure 1.Location of Bab louta dam [10].

1.2 Methodology

The two sampling companies were conducted during the month of February 2014 and during the month of November 2014. All the physic-chemical parameters have been analyzed in situ according to the method described in table 1:

Table 1.Method of Analysis of physic-chemical parameters

Parameter to analyze	Method of Analysis	reference
Temperature	Thermometer of 0.5 °C of Uncertainty	----------------
Dissolved oxygen	Portable oximeter	(NF EN ISO 5814, October 2012) [11].
pH	pH meter	(NF EN ISO 10523, May 2012) [12].
Turbidity	Turbidity meter	(NF EN ISO 7027, August 2016) [13].
Manganese	Analysis kit of manganese 0.03-0.5 mg/l -Mn	(VISOCOLOR HE, 2012) [14].
Penetration of the light	Secchi disk	(NF EN ISO 7027, August 2016) [13].

2. Results and Discussion

2.1. Study of stratification on February 2014

During the company of sampling on February 2014, in order to carry out a study of stratification of the dam, we have obtained the following results:
The values of the temperature are expressed in (°C) as a function of the depth in (m) (table 2), and then they are transformed into a vertical temperature profile (figure 2).

Table 2: The values of the temperature in (°C) as a function of the depth (m)

Depth (m)	Temperature (°C)
0.2	12.1
1	11.8
2	11.4
3	11.4
5	11.2
6	11.1
7	10.9
8	10.7
9	10.7
10	10.7
11	10.7
12	10.6
13	10.6
15	10.5
16	10.5
20	10.4
22	10.4
25	10.4

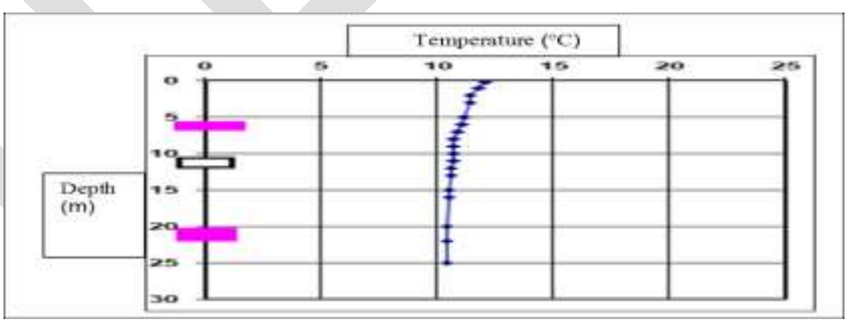

Figure 2.Vertical temperature profile

: Represents the level n° II of the water intake.
: Represents the current level n° I and III of the water intake.

The values of dissolved oxygen are expressed in (°C) as a function of the depth (m) (table 3), and then they are transformed into a vertical dissolved oxygen profile (figure 3).

Table3. The values dissolved oxygen (mg/l) as a function of the depth (m)

Depth (m)	dissolved oxygen (mg/l)
0.2	7.73
1	7.55
2	7.52
5	7.25
6	7.59
7	7.91
8	7.77
9	7.22
10	1.8
11	0.4
12	0.13
13	0.04
15	0
16	0
17	0
20	0
23	0
24	0
25	0
26	0

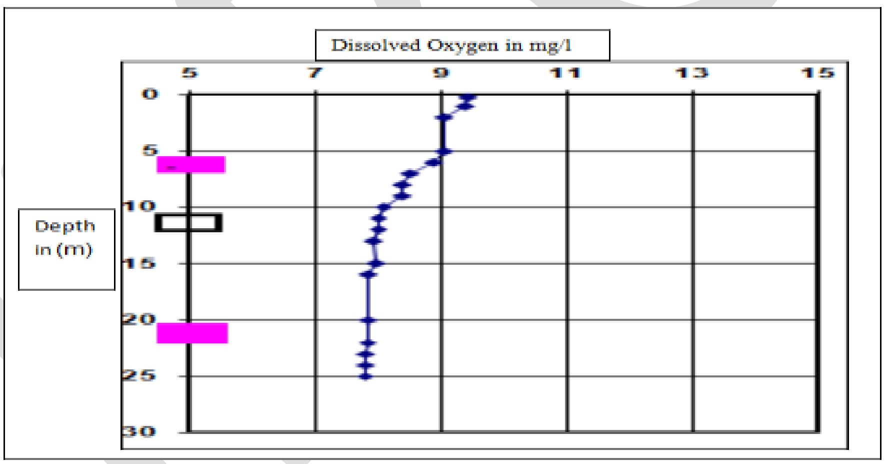

Figure 3.Vertical dissolved oxygen profile

The values of pH are obtained as a function of the depth in m (table 4), and then they are transformed into a vertical pH profile (figure 4).

Table4. The values of pH as a function of the depth (m)

Depth (m)	pH
0.2	8.28
5	8.26
8	8.22
10	8.20

13	8.20
15	8.16
20	8.16
22	8.11
25	8.10
26	8.09

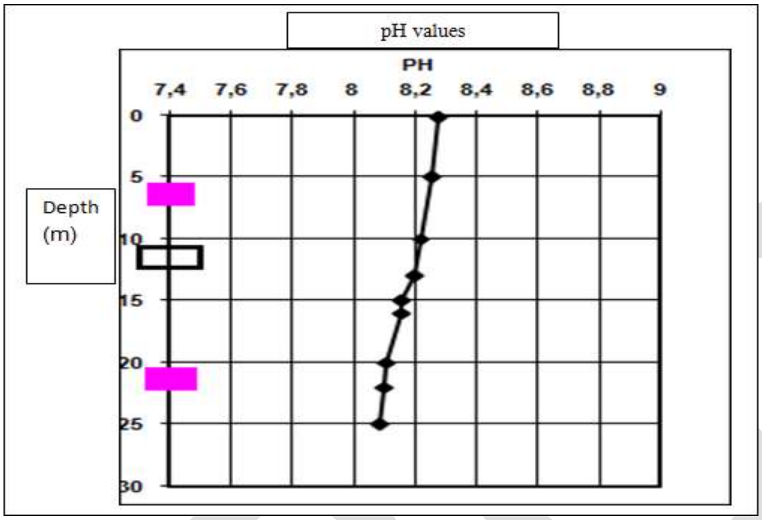

Figure4.Vertical pH profile

The values of turbidity are expressed in (NTU) as a function of the depth (m) (table 5), and then they are transformed into a vertical turbidity profile (figure 5).

Table 5.The values of turbidity as a function of the depth in m

Depth (m)	Turbidity (NTU)
0.2	32.4
5	47.3
10	61.3
13	105
15	120
20	125
22	131
25	140
26	164

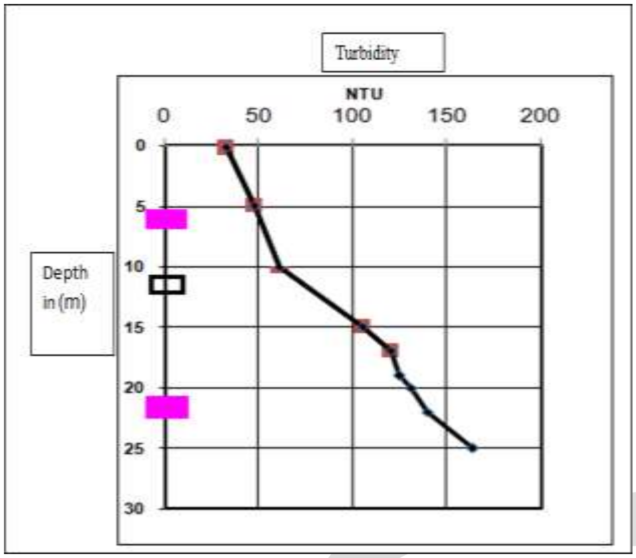

Figure 5.Vertical turbidity profile

2.2. INTERPRETATION 1 OF RESULTS

The study of stratification for the month of February gave the following results:

- ✓ The temperature difference between the surface and the bottom of the retainer is 1.7°C; so the total mass of water is almost de-stratified because of its brewing thus contributing to the cancellation of the thermocline (figure2).
- ✓ Dissolved oxygen levels fluctuate between 9.45 mg/L in surface waters and 7.8 mg/L in the waters of the bottom of the retainer. In effect, the atmosphere being the largest reservoir of oxygen, its dissemination to the water column to the air/water interface is carried out by a slow process and the effectiveness of these gaseous exchanges depends on the degree of oxygen saturation of the surface water. [15].
- ✓ The pH values measured in the range between 8.28 units in surface waters and 8.09 pH units at the bottom of the retainer. In effect, the surface waters are warmer compared to those of the bottom, and since the pH and temperature vary in the same direction, this explains the values of pH. In addition, the assimilation of carbon dioxide by plants is directly linked to the increase in photosynthesis which gives high values of pH at the layer epilimnion [16].
- ✓ Turbidity values obtained vary between 32.4 NTU in surface waters and 164 NTU in the waters of the bottom of the retainer. In effect, in the hypolimnion layer that is where are concentrated the materials in suspension that settle by gravity.
- ✓ The penetration of the light is evaluated at 40 cm. This penetration depends on the degree of the clarity and transparency of the surface waters. In this case, this low value of penetration of light due to the high values of turbidity.

2.3. STUDY OF STRATIFICATION ON NOVEMBER 2014

Concerning the company of sampling of November 2014, we have obtained the following results:
The values of the temperature are expressed in (°C) as a function of the depth (m) (table 6), and then they are transformed into a vertical temperature profile (figure 6).

Table6.The values of the temperature in (°C) as a function of the depth (m)

Depth in m	Temperature in °C
0.2	18.3
1	18.7
2	18.8
3	18.8
5	18.8
6	18.8
7	18.8
8	18.8

9	18.7
10	16.5
11	15.2
12	14.2
13	13.6
15	13.2
16	13.2
20	13.0
22	13.0
25	13.0

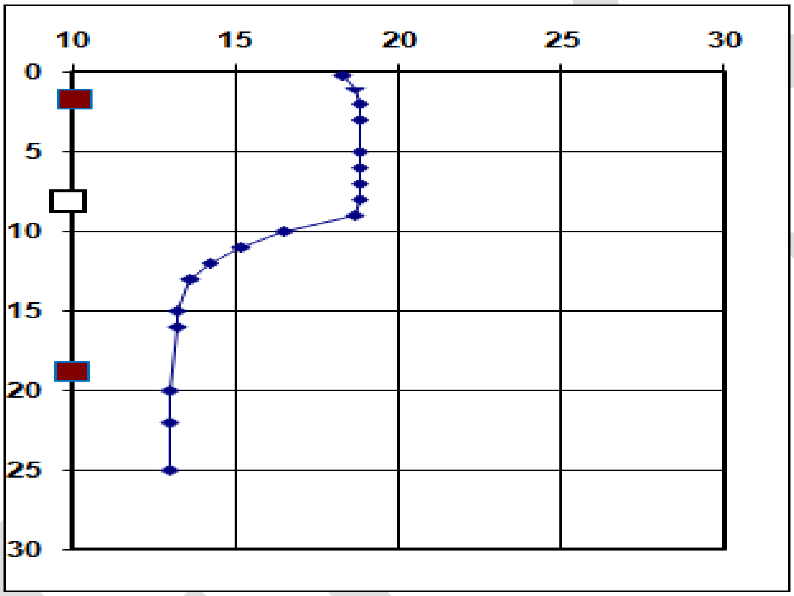

Figure 6.Vertical temperature profile

The values of dissolved oxygen are expressed in (mg/l) as a function of the depth (m) (table 7), and then they are transformed into a vertical dissolved oxygen profile (figure 7).

Table7.The values dissolved oxygen (mg/l) as a function of the depth (m)

Depth in m	dissolved oxygen in mg/l
0.2	7.73
1	7.55
2	7.52
5	7.25
6	7.59
7	7.91
8	7.77
9	7.22
10	1.8
11	0.4
12	0.13

13	0.04
15	0
16	0
17	0
20	0
23	0
24	0
25	0
26	0

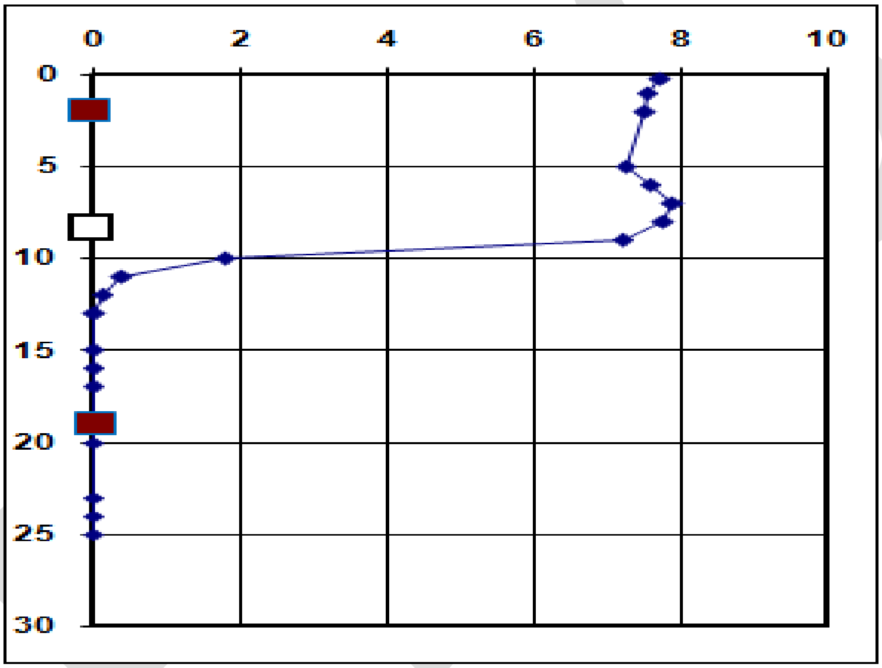

Figure 7.Vertical dissolved oxygen profile

The values of pH are obtained as a function of the depth (m) (table 8), and then they are transformed into a vertical pH profile (figure 8).

Table8. The values of pH as a function of the depth (m)

Depth in m	pH
0.2	8.48
5	8.68
8	8.27
10	8.27
13	8.20
15	8.04
20	7.95
22	7.90
25	7.90
26	7.89

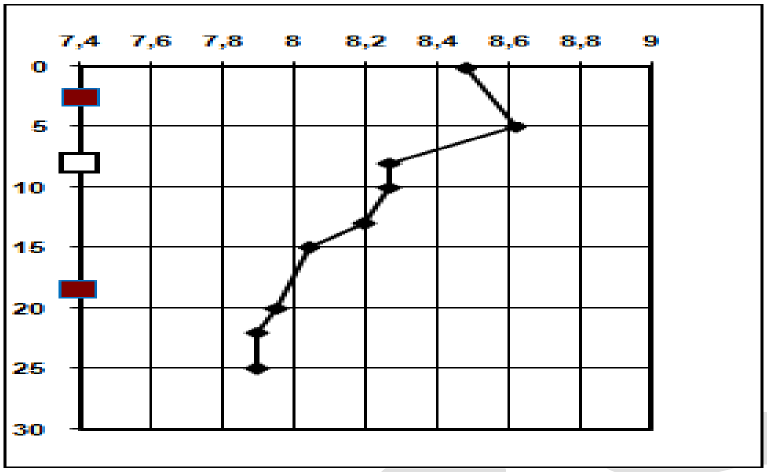

Figure8. Vertical pH profile

The values of manganese are expressed in (mg/l) as a function of the depth (m) (table 9), and then they are transformed into a vertical dissolved oxygen profile (figure 9).

Table 9.The values of manganese as a function of the depth (m)

Depth in m	Manganese content in mg/l
0.2	0
5	0
10	0.2
12	0.5
15	0.6
17	0.7
20	0.7
22	0.7
25	0.8
26	0.8

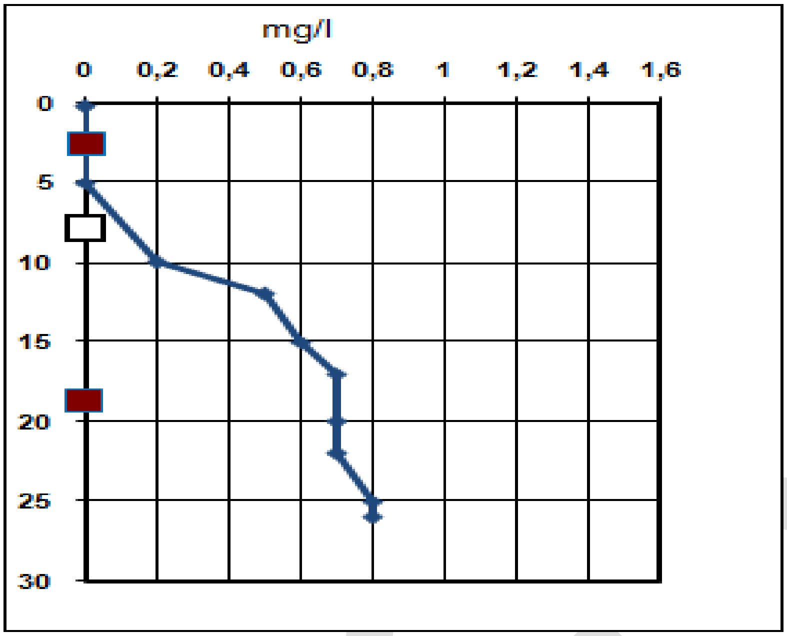

Figure 9.Vertical manganese content profile

2.4. Interpretation 2 of results

The results of analyzes of stratification relating to the sample of November 2014 show what follows:

- The temperature difference between the surface and the bottom of the retainer is 5.3°C so that the total mass of water is stratified. This stratification, which is manifested by the training of different layers are quite distinct, is due essentially to the heating of the mass of water; and by difference in densities, we have obtained this temperature difference.
- An anoxia of waters of the retainer from 14 m depth. It is from this level where it begins to have high manganese content (0.55 mg/l) and this as a result of the depletion of dissolved oxygen resulting in algal activity and the release of the organic matter.
- The pH values measured vary between 8.48 units in surface waters and 7.89 pH units at the bottom of the retainer.
- Concentrations of manganese obtained vary between 0.2 mg/L at 10 m depth and 0.8 mg/L in the bottom of the retainer. This explains well the existing correlation between anoxia and concentrations of manganese.
- The penetration of the light is evaluated at 180 cm. During this period, the low values of turbidity involve a penetration of important light compared to the winter period.

Acknowledgment

My thanks go to the whole team of the service limnology of the Central Laboratory of the National Office of Electricity and Water potable.

CONCLUSION

The current study of stratification conducted on the mass of water of Bab louta dam has shown that the intake level n° II remains the most recommended from which the raw water must be drawn to feed the water treatment plant and ,therefore, to save the reagents which are used in the treatment process. This choice is based on criteria which must meet the quality of the raw water.

This solution is not considered unique but it remains necessary by adopting other solutions such as the biological solution by putting the silver carp in the retainer of dam.

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