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PHYSICOCHEMICAL QUALITY OF WATER OF AN URBAN POND NORTH-EAST OF ALGERIA

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ABSTRACT

The Tamlouka pond is the only urban water feature of the highland wetland eco-complex; located northeast of Algeria. This pond is extremely threatened by the risks of agricultural and industrial pollution and the intensification of urbanization. It receives wastewater discharges directly from cities and neighbouring municipalities. To assess the evolution of its state of health and its impact on the environment and public health, physicochemical analysis of the water of this pond were carried out during the year (2015-2016). Twelve parameters were measured: Temperature (T), pH, Electrical Conductivity (EC), Total Hardness (TH), Phosphates (PO_4^{3-}), Dissolved Oxygen (DO), Organic Matter (OM), Calcium (Ca^{2+}), Magnesium (Mg^{2+}) and nitrogen compounds. The water samples were collected from six sampling stations (S1, S2, S3, S4, S5, and S6) selected according to the urbanization of the watershed and the hydrological importance of the effluents and discharges. It has been noticed from the analysis of various water sampling stations the presence of nitrogen compound and PO_4^{3-} with an increasing gradient at stations S4 and S5. Waters in stations S1 and S2 are strongly mineralized, where electrical conductivity levels have exceeded 9350 µS/ Cm. Principal Components Analysis (PCA) revealed two gradients: the first represents the degree of organic pollution, while the second describes the mineralization of the waters to address the main causes of pollution.

KEY WORDS : Pollution, Urbanization, Water Quality, Physicochemical

INTRODUCTION

The Mediterranean basin is a recognized hot spot (*hotspot*) of biodiversity, it is also a hot spot of human population growth (Cincotta and Engelman, 2000), its wetlands are a remarkable natural heritage, and they have become a more valued environment (Williams, 1991).

The multiple anthropogenic impacts that weigh on the ecosystems of the Mediterranean basin strongly threaten this unique biological and evolutionary inheritance and determine their dynamics (Frédéric and Katia, 2006). These systems consist of physicochemical, ecological, modified and man-made components (Eliane *et al*., 2002), which poses inevitable conservation problems.

The industrialization, the non-rational use of fertilizers, pesticides and lack of awareness of the population toward the protection of the environment lead to an imbalance in the ecosystem and generate polluting elements that can affect the physicochemical and biological quality of the aquatic receptors (Mulliss *et al.*, 1997).

Now most wetland studies are about their loss, through various human used and about methods of measuring mitigating human impacts such as agriculture, urban, industrial and port development, recreation and dumping which affects all of these (Williams, 1991).

The highlands of eastern Algeria include one of

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the largest and most diverse wetland complexes in the country. The Tamlouka pond is the only urban water body in the region. This pond is extremely threatened by the risks of pollution and the intensification of urbanization. Although it receives wastewater discharges directly from cities and neighboring municipalities, it is the open-air receptacle for waste deposits.

The objective of this study is to evaluate on the one hand, the degree of pollution which affect Tamlouka pond water, determine the potential causes of this pollution and their influence on the evolution of the physicochemical parameters. On the other hand, examine the typology of water pollution by Principal Component Analysis method.

MATERIALS AND METHODS

Located in the north-east of the Algerian territory, the study area is about 60 km south of the city of Guelma and 30 km north of the city of Oum El Bouaghi, it lies between 36° and 36° 12′ N latitude; 7° and 7° 15′ E longitude, where it belongs to the region of the high plateaus (high plateaus of Constantinois) (Hemila and Kowalski, 2002). Whose average altitude is greater than 800 meters with however slight slopes.

The Tamlouka pond is located south of the town of Tamlouka facing the path of Wilaya N° 102, connecting Wilaya Oum El Bouaghi and Guelma, has an oval shape, surrounded to the northwest by agglomerations. In the East, and in the South-east is the plain of Tamlouka. The banks of the pond are occupied by the discharge of the municipality. The high plateaus region is considered to be a semi arid area with a warm summer and low temperature in winter. Temperature rises up to 40 °C in summer (Gueroui *et al*., 2015). The majority of its aquatic ecosystems, whose impoundment is very dependent on rainfall, dry up as early as June (Houhamdi *et al*., 2009).

The water samples were collected from six sampling stations (S1, S2, S3, S4, S5, and S6). They were selected according to the urbanization of the watershed and the hydrological importance of the effluents and discharges; we did a monthly follow-up over 12 months from December, 2015 to November, 2016, Fig. 1.

The methods used for the physicochemical analysis are volumetric, colorimetric and spectrophotometric according to Rodier's analysis protocol (Rodier, 2009). The following parameters: T, pH, Electrical Conductivity (EC) and Dissolved Oxygen (DO) were measured directly in situ using a suitable portable multi-parameter. For the analysis and interpretation of these results, a study of interdependence relations was conducted using Principal Component Analysis (PCA).

RESULTS AND DISCUSSION

The results of physicochemical analysis of Tamlouka

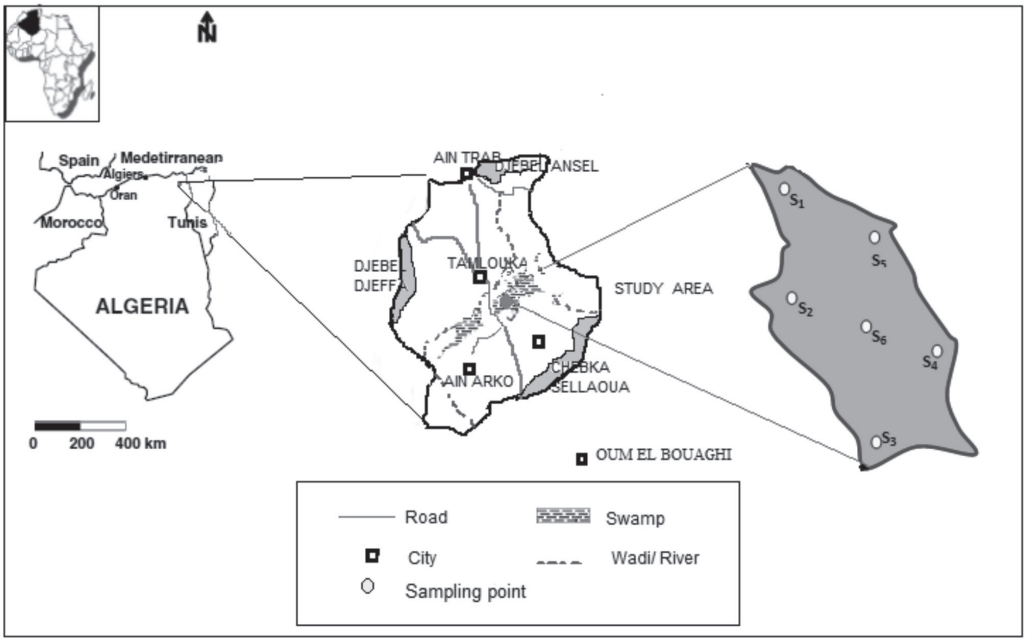


Fig. 1. Schematic map of the study area with locations of sampling points.

pond waters, measured for six stations are illustrated in Fig. 2. They are essentially pollution indicator parameters which have a large variation and some of the recorded values exceed the international standards of surface water.

Water temperature is a significant factor in organic production, because it affects the latter's physical and chemical properties (Ramdani and Laifa 2017). It is important to know it with good precision (Rodier, 2005). The water temperature of the Tamlouka pond fluctuates between 11,46 °C at station S2 and 32,86 °C at station S6 and it does not present large variations from one station to another (Fig. 2a). The temperature of the water is strongly influenced by the environmental conditions related to the situation geographical location of the locality, the geology of the areas crossed, and the hydrology of the ecosystem and especially to the climate prevailing (Resjek, 2002).

The pH of water represents its acidity or alkalinity (Dovonou *et al.*, 2011), it is a factor depending on the natural conditions of the environment (Reggam *et al*., 2015), and it is related to the nature of the lands crossed. This parameter affects many physicochemical balances, and it depends on many factors, including temperature and the source of water (Chapman and Kimstach, 1996). The pH measured values presented during the period of the study slightly alkaline pH and does not show large variations from one station to another, The lowest value (7, 8) was recorded at station S6 in the period of high water ; The value of 8,89 was recorded at stations S6 and S5 in low water period (Fig. 2b).

Measurement of water conductivity is used to assess the quantity of salts dissolved in water (Rodier, 2005), and it is one of the ways to validate the physicochemical analysis of water. Indeed, the contrasts of conductivity measured on a medium allow to highlighting pollutions, zones of mixing or infiltration (Ghazali and Zaid, 2013). The analyzed waters have very high levels in the electrical conductivity varies considerably from one season to another and fluctuates between 1060 µS/Cm at station S3 and 9350 µS/Cm at station S2 which reflects a strong mineralization (Fig. 2c). These high values are due either to an increase in the inputs of dissolved substances from the watershed and the agricultural lands surrounding the pond, or to the gradual increase of the temperature. The latter intervening through the process of evapotranspiration which favors the concentration salts in water and conductivity (Resjek, 2002). However, the minimum values are related to the high dilution of water during the month of January.

Dissolved Oxygen participates in the majority of chemical and biological processes in aquatic environments (Ghazali and Zaid, 2013). Its content provides information on the metabolic activities of the environment (Dovonou *et al.*, 2011). At all stations, its maximum concentration is below 2,21 mg/L. This hypoxia reaches its minimum in October (0.52 mg/L) at station S2 (Fig. 2d) and can be explained by the abundance of organic matter.

Domestic waste contributes to the reduction of O_2 content, the latter being consumed by microorganisms to degrade organic matter (Toumi *et al.*, 2016). The maximum values are recorded during the period from March to June at all stations except that of the middle of the pond (S6) which is caused by the abundance of vegetation which characterizes these stations of banks.

Organic matters (OM) are oxidizable materials which require for their decomposition a certain quantity of oxygen and they contribute significantly to oxygen demand and result in decreased concentration of dissolved oxygen in the aquatic environment, they are going to impoverish the natural environment from oxygen. The presence of organic matter will promote anaerobic action leading to the accumulation of toxic compounds in the water bodies and deterioting them leading to death of the pond (Goel, 1997). This indicates that the effluent is unsuitable for the existence of the aquatic organism in water bodies. (Gershome and Dawood, 2012).

Measuring this oxygen demand allows to evaluate the contents of a water in biodegradable organic matter, so its degree of pollution or its quality. That is the reason behind considering them as polluting materials (Dovonou *et al.*, 2011). The high values (9,13 mg/L) are recorded at station S6. It appears, however, that this station is the most affected by pollution (Fig. 2e).

Water total hardness (TH) is a parameter directly linked to the amount of calcium and magnesium (Reggam *et al*., 2015). The results obtained show that the waters studied have significant hardness ranging from 49 °F at station S6 to 119 °F at station S4 (Fig. 2f). The origin of the hardness of water can be linked simply to the lithology of the banking terrain or to external factors such as pollution. The Guelma Basin has gypsum marl bedrock that can explain the abundance of calcium throughout the

plain. Magnesium can come from carbonated (travertine) and marlant rocks (Zeddouri, 2003).

Calcium is the most dominant cationic element in surface waters and it is generally found as soluble bicarbonate (Bermond and Vuichaard, 1973) constituting the hardness of water and its content varies mainly according to the nature of the terrain crossed. Concentrations of Ca^{2+} in Tamlouka pond waters ranged from 86,96 mg/L at station S6 to 184,2 mg/L at station S2 (Fig. 2g). The maximum content is recorded during the month of July and the minimum content during the month of March. This is explained by the phenomenon of dilution because at this level the volume of water is at its highest level. The presence of this element in the water has the origin of the dissolution of carbonate and gypsum formations.

According to the results of the Mg^{2+} analyze (Fig. 2h), we notice that the magnesium level in Tamlouka pond varies from 32,95 mg/L at station S6 to 212,08 mg/L at station S2. It is during period of high water that the concentration of this element decreases under the effect of dilution which is often related to the geological formation and climatic characteristics of the region.

Phosphates are one of the nutrients the most important in nature. They meet in natural waters, domestic and agricultural wastewater. They are formed as a result of the decomposition of the organic matter. It represents a biogenic element essential for the growth of algae, bacteria and protozoa (Resjek, 2002). The increase in phosphates fluxes in surface waters is the result of increased population pressure and agricultural activities in watersheds (Sayad, 2008; Reggam *et al*., 2017a). As a result of the assays carried out, the important values of phosphates were recorded at stations S4 and S5 15, 73 mg/L and 15,98 mg/L respectively (Fig. 2i). This is due to the urban activities (accumulation of detergents used by residents) and the leaching of the surrounding agricultural land with enormous amounts of fertilizers in addition to the direct exposure of these stations to the deposits. Too much phosphate can cause eutrophication or over fertilization of streams, especially if large amounts of nitrates are present (Kelome *et al*., 2018).

Ammonium ions content from 0.78 mg/L to 8.87 mg/L (Fig. 2j). The minimum values calculated during the month of January at station S6, while the maximum values calculated during the month of April at station S5.

The presence of ammonium ions in large quantities is the index of contamination by releases of human or industrial origin. Human or animal urine contains large amounts of urea which rapidly convert to ammonium. This parameter is often used as a tracer for domestic wastewater.

Nitrites constitute the intermediate stage between ammonium ions (NH_4^+) and nitrate ions (NO_3^-) (Abba, 2008). It comes from the reduction of nitrate ions under the influence of bacteria (Dovonou *et al*., 2011). They are only met when there is an imbalance in the oxygenation or bacterial flora (Eliane *et al*., 2002). It is considered to be a toxic element. Their presence indicates a critical state of organic pollution. During our study period, the concentrations of nitrite ions were unstable and ranged from 0.18 mg/L at station S2 to 2.95 mg/L at station S4. The highest values are recorded during the month of September (Fig. 2k).

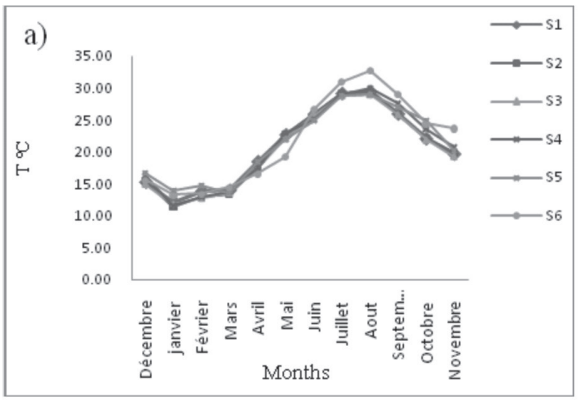
Nitrate ions were the final stage of nitrogen oxidation (Ramdani and Laifa, 2017). This ion is found naturally and is the most stable form of combined nitrogen for oxygenated systems. It also serves as an essential source of nitrogen for plants. It is a widespread contaminant as it is highly water soluble (Sanjiv *et al.*, 2018). Their concentrations in Tamlouka pond fluctuate between 2.2 mg/L at station S2 and 66.5 mg/L at station S5. The high values are recorded during the month of May (Fig. 2l), because of the decomposition of the organic matter and the leaching of the surrounding farmlands loaded huge amounts of fertilizers. The high concentrations of nitrates can cause many health complications such as methemoglobinemia in humans, and unable blood transport to tissues (Kelome *et al*., 2018; Sanjiv *et al*., 2018) and in the long term, it can be carcinogenic (Bonton *et al*., 2010).

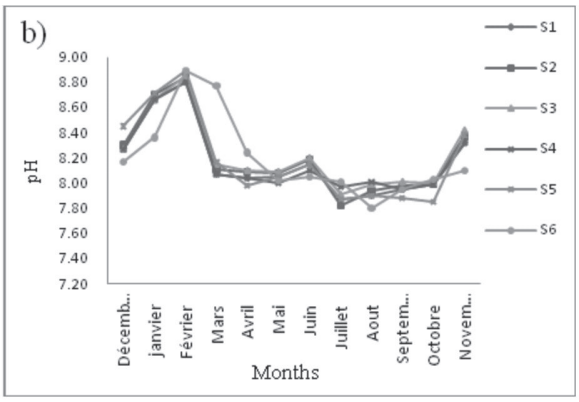
STATISTICAL ANALYSIS

The PCA was carried out on a data matrix, which the 12 variables (pH, T, EC, DO, NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, MO, TH, Ca^{2+}, Mg^{2+}) were measured. The correlation matrix of the 12 parameters measured during our study is presented in Table 1. In bold are represented significant values ($p < 0, 05$).

CORRELATION MATRIX

The total hardness is well correlated with calcium and magnesium ($R = 0.91$ and $r = 0.87$ respectively). The good correlation between phosphates and


a)
T °C
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Décembre
janvier
Février
Mars
Avril
Mai
Juin
Juillet
Aout
Septem...
Octobre
Novembre
Months
S1
S2
S3
S4
S5
S6


b)
pH
9.00
8.80
8.60
8.40
8.20
8.00
7.80
7.60
7.40
7.20
Décemb...
janvier
Février
Mars
Avril
Mai
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Months
S1
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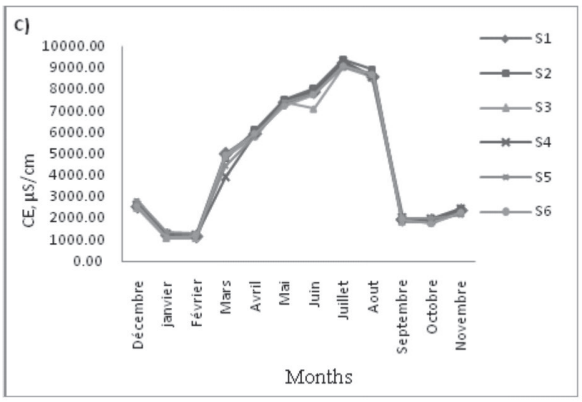
S6


c)
CE, µS/cm
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
Décembre
janvier
Février
Mars
Avril
Mai
Juin
Juillet
Aout
Septembre
Octobre
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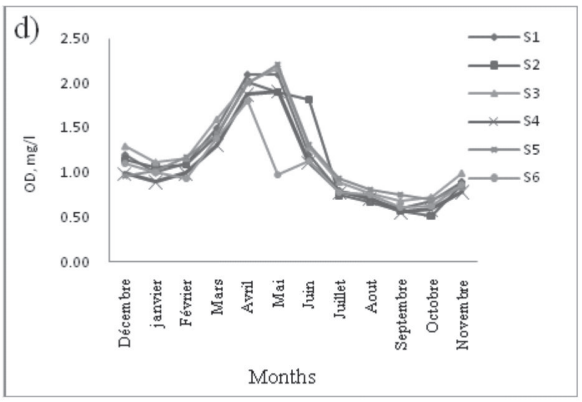
S6


d)
OD, mg/l
2.50
2.00
1.50
1.00
0.50
0.00
Décembre
janvier
Février
Mars
Avril
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Months
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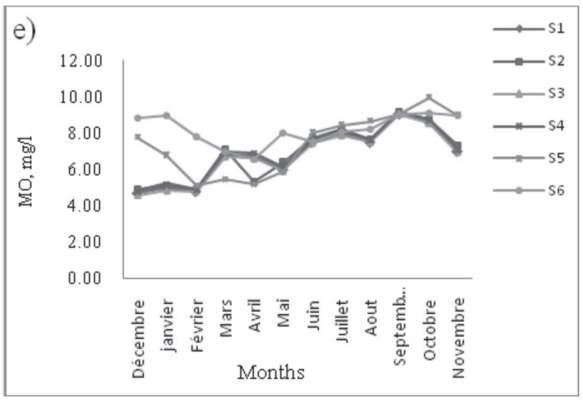
S6


e)
MO, mg/l
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Décembre
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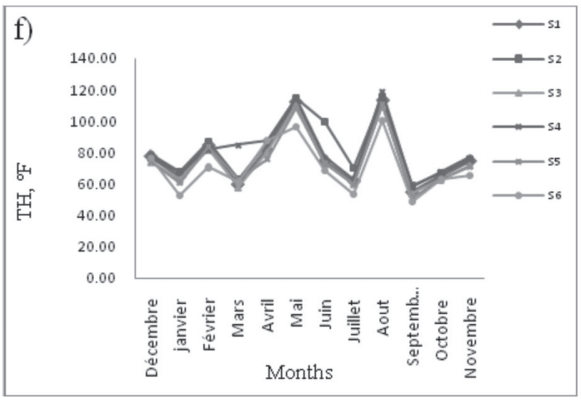
f)
TH, °F
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Décembre
janvier
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Mars
Avril
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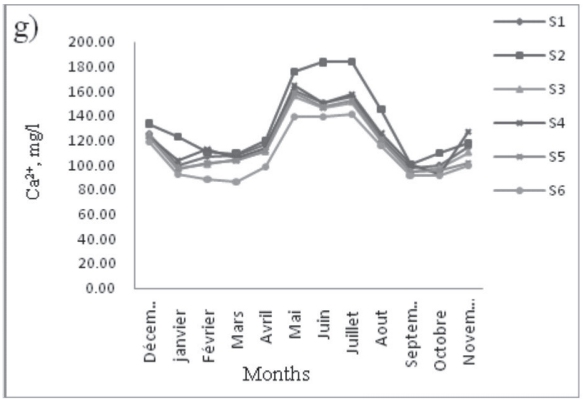
g)
Ca2+, mg/l
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Décem...
janvier
Février
Mars
Avril
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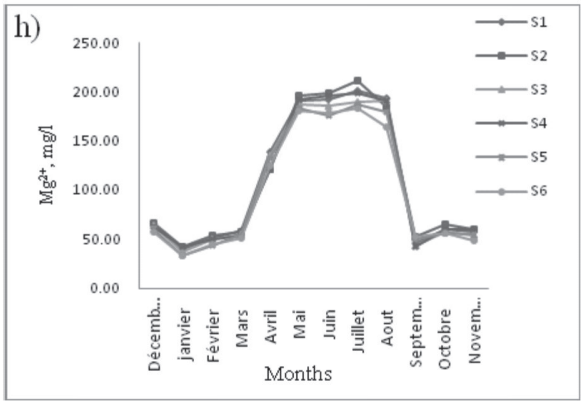
h)
Mg2+, mg/l
250.00
200.00
150.00
100.00
50.00
0.00
Décemb...
janvier
Février
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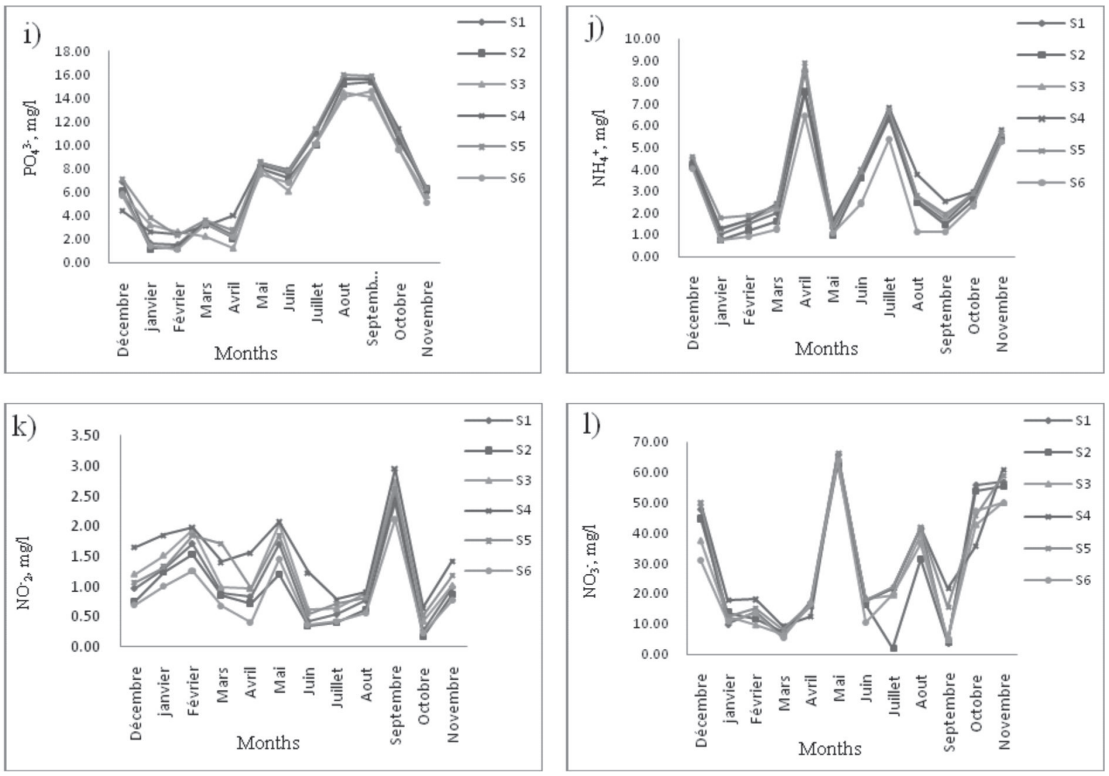

Fig. 2. Physicochemical parameters of water of Tamlouka pond : a) Temperature (T), b) pH, c) Electrical Conductivity (EC), d) Dissolved oxygen (DO), e) Organic Matters (OM), f) Total Hardness (TH), g) Calcium (Ca^{2+}), h) Magnesium (Mg^{2+}), i) Phosphates (PO_4^{-3}), j) Ammonium ions (NH_4^+), k) Nitrites (NO_2^-), l) Nitrates (NO_3^-).

nitrates (r = 0.96) could indicate water degradation (the eutrophication phenomenon).

A positive correlation between ammonium and nitrite (r = 0.89) is related to human activity such as wastewater and agricultural activities. Strong and positive correlations were observed between temperature and nitrates (r = 0.90) on the one hand and between temperature and phosphates on the other hand (r = 0.98). A rise in temperature could therefore promote the development of algae.

PRINCIPAL COMPONENT ANALYSIS

The statistical treatment was driven by two factorial axes (F1 and F2), which express respectively 47.17% and 23.55% of the total variance of the point cloud,

Table 1. Correlation matrix of the different physicochemical parameters studied at the level of Tamlouka pond.

	pH	T°C	CE	OD	NO_3^-	NO_2^-	NH_4^+	PO_4^{3-}	MO	Ca^{2+}	Mg^{2+}	TH
pH	1,00	-0,40	-0,48	0,48	-0,59	-0,06	-0,01	-0.53	-0.15	0.01	-0.09	-0.18
T°C		1,00	0,32	0,31	0,90	0,61	0,76	0.98	-0.33	0.36	0.28	0.44
CE			1,00	-0,13	0,13	-0,30	-0,18	0.28	-0.12	0.73	0.53	0.63
OD				1,00	0,08	0,17	0,56	0.19	-0.65	0.34	0.40	0.12
NO_3^-					1,00	0,75	0,77	0.96	-0.27	0.12	0.19	0.35
NO_2^-						1,00	0,89	0.62	-0.47	0.08	0.21	0.38
NH_4^+							1,00	0.73	-0.67	0.26	0.39	0.41
PO_4^{3-}								1.00	-0.23	0.23	0.19	0.35
MO									1.00	-0.69	-0.89	-0.70
Ca^{2+}										1.00	0.88	0.91
Mg2+											1.00	0.87
TH												1.00

Bold numbers indicate significant correlations

which is a cumulative inertia of the two axes of 70.72% of the total information (Fig. 3, 4).

In general, the main axis of inertia F1 expresses 47.17% of the variance. It is positively defined by organic matter and negatively by temperature, dissolved oxygen, nitrates, nitrites, ammonium ions and phosphate (Fig. 3). This axis can be likened to a pollution gradient by NO_3^-, NO_2^-, NH_4^+ and PO_4^{3} Thus the pollution of the pond's water is caused by human activities (wastewater and agricultural activities).

The axis of inertia F2 expresses 23.55% of the variance. Fig. 3. It is negatively defined by conductivity, calcium and magnesium (Fig. 3). This axis can be assimilated to the mineral character of the waters defined by conductivity, Ca^{2+} and Mg^{2+}.

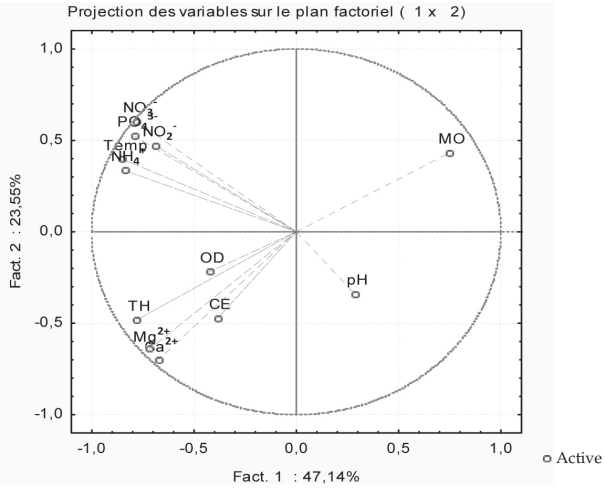

Fig. 3. Circle (I-II) variables

These two axes allow subdividing the plane of individuals into three groups of stations that differ in their physicochemical quality (Fig. 4).

Group 1: characterizes the points whose waters are strongly mineralized. These waters have a high conductivity and are characterized by the presence of calcium and magnesium ions. These are the waters of the station S1 which is in the negative part of the component 1 and the station S2 which is in the negative part of the component 2.

Group 2: characterizes the points whose waters are strongly affected by human activities and therefore not very mineralized. These waters have higher concentrations of NO_3^-, NO_2^-, NH_4^+ and PO_4^{3}. This group represented by stations S4 and S5. These stations are characterized by the phenomenon of eutrophication (Fig. 4).

Group 3: characterizes the points whose waters are weakly mineralized and strongly affected by the urban activity. It has high contents of organic matter represented by the stations S3 and S6.

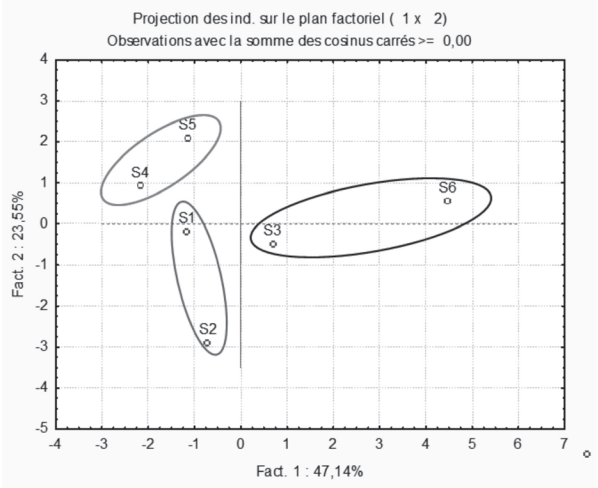

Fig. 4. Plan (I-II) of individuals

CONCLUSION

In the light of these results, human activities, disorderly exploitation of water resources and hydrological and climatic conditions have had a negative impact on the physicochemical quality of surface water, thus on the environment and public health. This pollution constitutes a major threat to the health of this ecosystem. These areas are particularly problematic and their protection remains one of the major issues of our decade.

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