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Hydrobiological study of the source Tadout (Middle Atlas, Morocco): Physical chemistry, microbiology and benthic fauna

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Key words: Macrofauna, physicochemical quality of waters, Microbiological assessments, the ecosystem, specific fairness, diversity index, Arthropods, microbiological quality

Abstract

The objective of the present work is to study the physicochemical and microbiological quality of the waters of the source Tadout as well as the structure and the spatio-temporal distribution of macroinvertebrates inhabiting this aquatic ecosystem. The results of the physicochemical analyzes have revealed that the waters of the source are cold, mineralized, hard and affected by an organic pollution. However, the values found are lower than the permissible limits of the Moroccan standard**.** Concerning microbiological assessments, the results were high and exceeding standards values fixed by the regulatory framework of surface water. As for the benthic fauna, the analysis of the taxonomic composition of the species identified in this resurgence made it possible to highlight the presence of 1973 individuals belonging to 17 families,22 genera and 27 species.This ecosystem is mostly dominated by the Arthropods (63, 03%), followed by the Molluscs (26,3%) and finally the annelids which are the least inventoried (4.9%). In addition, the results show that the source Tadout is marqued by a low diversity index and specific fairness.

Introduction

It is recognized internationally that currently wetlands, play a crucial role in the maintenance of life on earth in the same title that agricultural land and forests. Morocco is the country of North Africa best equipped with wetlands compared to other Maghreb countries. This is related in large part to its geographical location, which gives it a coastal area of more than 3500km and four mountain ranges including the Middle Atlas (MA) wich is the driving part. The high altitude of its well watered reliefs as well as the predominance of phreatic and superficial waters generate a multitude of generally fresh sources with high flow. . In addition to their socio-economic value, it is incumbent upon us to consider the ecological importance of the sources in that they are biotopes that usually contain a wide variety of life forms among which benthic macroinvertebrae are the cornerstone.

Its exceptional singularities combined with its paleogeographic antecedents make the sources of the average atlas of sites suitable for faunistic and biogeographical studies [1,2,3,4,5,6,7,8,9,10,11]. However, an exhaustive reading of the scientific literature reveals a great deficiency in terms of faunistic, physicochemical and microbiological studies that make it possible to define the quality of these aquatic ecosystems and better monitor them to detect the impact of the different disturbances on these environments. This could help decision-makers to take or reinforce the conservation measures of these wetlands endowed with an ecological, historical and human value, as old as the history of Morocco.

In order to fill these knowledge gaps, we have realized this study which main goal is the determination of the global composition and the monitoring of the dynamics of macro-benthic faunal community of the source Tadout in relation to the main abiotic factors of the environment.

Material and methods

1- Study area :

Tadout is the biggest source of the Skoura region. Its altitude is 1300 m. This aquatic ecosystem arises on the eastern part of Jebel Tichoukt, about thirty kilometers north east of Boulmane. It can be reached by the road which is located at the north-east of Boulmane city towards Skoura for a distance of 33km; the source is located almost 3 Km of Skoura (**Fig1**). It is formed of a main source converted into a watering trough and almost entirely canalized for irrigation and a secondary source which remained natural. Our samples were taken from the second source. The average flow observed at this aquatic ecosystem is 3541 / s with a very strong current which is gradually reduced downstream. The spring water is used for drinking water supply to the surrounding douars and irrigation. The substrate is formed of blocks and pebbles covered respectively with Bryophytes and herbaceous vegetation.

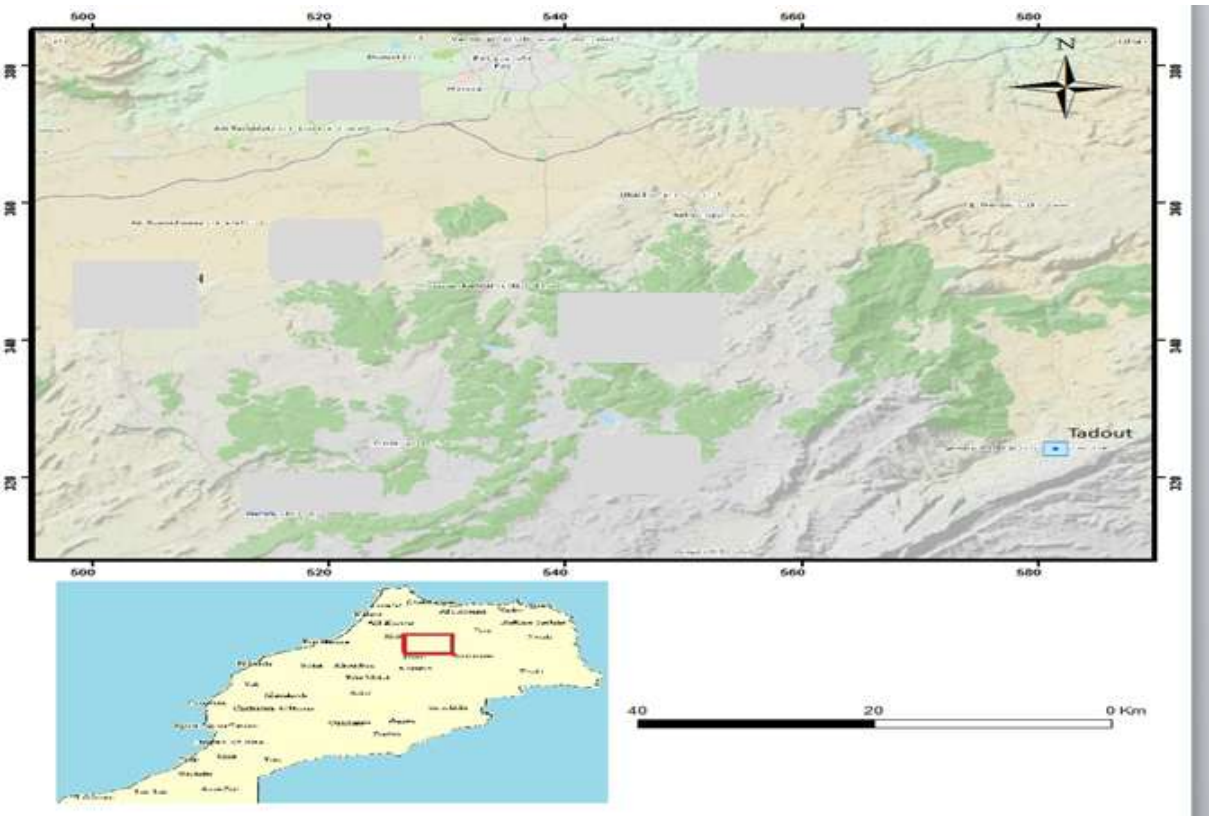

Figure 1 : Location of sampling station

2- Sampling :

2-1 Physicochemical parameters

The chemical composition of the waters of springs is mainly acquired during the crossing of the soil and its stay in the reservoir. The water, in contact with surrounding rock acquires a mineral charge characteristic of the rocks crossed. In order to evaluate the physico-chemical quality of the ground water of the source Tadout, a seasonal survey of the water samples was carried out during one year: During each season, two samples were taken resulting in a total of 8 sampling campaigns covering the year 2015-2016. According to WHO recommendations, water samples intended to physicochemical analyzes were collected in polyethylene bottles from the main resurgence and were stored at 4 ° C during transport to the laboratory for analysis within 24 hours following. Analytical methods are those recommended by the standards[**12 ;13**]**.**

Measurements of temperature, pH, and electrical conductivity were carried out in situ using a CyberScan PC10 multi-parameter pH/conductivity/temperature analyzer. The methods used are: volumetry for dissolved oxygen, bicarbonates, chlorides, calcium and magnesium and molecular absorption spectrophotometry for sulphates and ortho phosphates (**Table 1**).

Table 1: Chemical component analysis method

Parameters	Unit	Measuring equipment and method of analysis
Temperature	° C	Analyzer multi parameters Cyber Scan
Conductivity	µS/cm	Analyzer multi parameters Cyber Scan
pH		Analyzer multi parameters Cyber Scan
Dissolved O_2	mg/l	Winkler method
Calcium hardness	mg/l	EDTA Complexometry of with calcone
Magnesium hardness	mg/l	Difference between total and calcium hardness
Alkalinity	meq/l	Volumetric dosing with sulfuric acid and methyl orange
Permanganate index	mg/l	Oxidizability of hot potassium permanganate
Chlorides	mg/l	Metering,with Mohr method
sulphates	mg/l	absorption spectrometry at 650 nm
Orthophosphates	mg/l	absorption spectrometry at 750 nm

2-2 Microbiological analyses

Microbiological analyzes are an essential tool of the health survey, because they make it possible to highlight the fecal pollution of water and to control the effectiveness of protection or treatment measures.

The campaign of water sampling for microbiological analyzes was carried out in the morning. Filtration and sowing in petri dishes was carried out in the afternoon of the same day. The methods used during this monitoring comply with Moroccan drinking water standards. The set of methods followed as well as the culture media recommended for each type of bacteria are indicated in **Table 2**. After incubation, the Colonial Forming Units (CFU) were counted macroscopically in each petri dish.

Table 2: Method of sampling and enumeration of bacteria

	Technique	Sampling volume	Culture medium	Incubation temperature
FMAT	Incorporation in solid medium	1 ml	Yeast extract agar	20°C et 37°C
Total coliforms	Filtration	100ml	Agar lactose to the TTC	37°C
Fecal coliforms	Filtration	100ml	Agar lactose to the TTC	44°C
Faecal streptococci	Filtration	100ml	Agar Slanetz	37°C

2-3 Benthic macrofauna

2 -3-1 Sampling technique

“The purpose of the sampling is to gather the most representative diversity of macroinvertebrates for each station examined » [**14]**.

Samples of macroinvertebrates were collected in parallel with the samples for physicochemical analyzes using a "Surber" sampler that has a surface area of 1/20 m² (20x25 cm) and equipped with a mesh opening mesh of 500 µm. In order to collect the maximum of species colonising the source, We sampled the different microhabitats present on this site. The sampling method followed a standardized protocol by placing the "Surber" sampler on the bottom of the streambed facing the current, the sampler frame determines the area of the

microhabitat to be sample. The support is then either cleaned by hand (example: stones), either be scratched with a rake to a thickness of a few centimeters (example: sand) or possibly harvested in full (example: submerged plants).

It is important to note that the choice of micro-habitats was made both according to their biogenic suitability (favorable to the aquatic life), their representativeness within the station and the different classes of speed of the current on the site.

2-3-2 Fixation of collecated species

In situ, the captured species were deposited in a white basin with water to facilitate their mobility and capture and also in order to eliminate the coarser elements (stones, pebbles, fragments of wood and leaves of plants). The samples are put in jars labeled (using standardized labels that we have prepared in advance) and fixed by formaldehyde in a way to have a final concentration of 4 to 10% of this preservative.

2-3-3 Sorting and identification of collecated species

Once in the laboratory, we sorted and identified the species harvested using the binocular loupe. To reach the family level, we have referred to the key **[15]**. But as we have aimed to achieve the 'species' taxonomic unit we had recourse to experts of different universities. Our employees are thanked for their contributions.

RESULTS AND DISCUSSION

1- Physicochemical parameters

-Temperature :

The temperature of the water is related to location of the locality, the geology of crossed land and especially the reigning climate. It has an important ecological impact**[16].** For the source Tadout, the temperature values recorded during the year of the study do not show large variations **(Figure 2)**. These values fluctuate between 18.1 ° C and 19.6 ° C. The highest temperature values were recorded in the summer while the minima marked the winter. The average value recorded is 20.66 ° C. the temperature values obtained at the level of this source are consistent with those found by [**17]** during their prospection of the same source.

Although the temperature values recorded at this aquatic ecosystem make it possible to classify it according to **[18]** among the cold sources, these values are high, especially considering altitude (1300); These results suggest that these waters do not have a superficial origin.

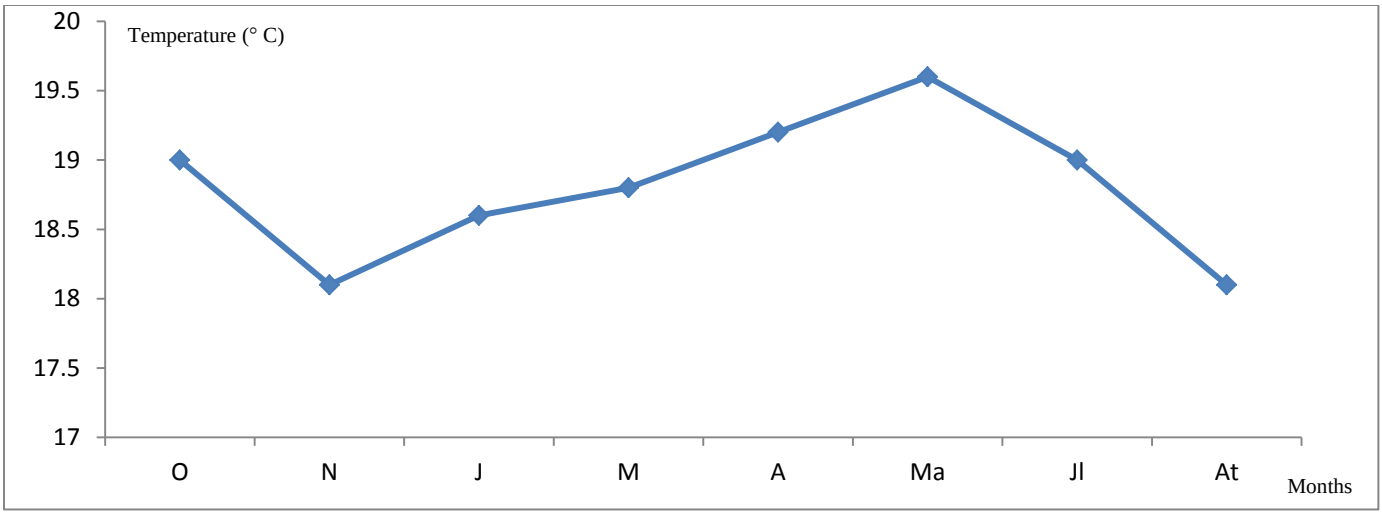

Figure 2: Spatiotemporal Variation of the temperature (° C) in the waters of Tadout during the year 2015-2016.

- **Ph**

Ph is a good indicator of water pollution; It decreases in presence of high organic matter levels and increases in low-flow period, when evaporation is important **[19].**In our sampling station, pH values are greater than 7 during the year of study **(Figure 3).** The average pH level is around 8.2. This low alkalinity is strictly related to the nature of the karst terrain crossed by the source in question. These results are in agreement with those found by [**20**] during their prospections of the sources belonging to the same hydrogiological unit of the source in question. Referring to the Moroccan standards[**21**], the quality of the waters of Tadout can be considered as acceptable.

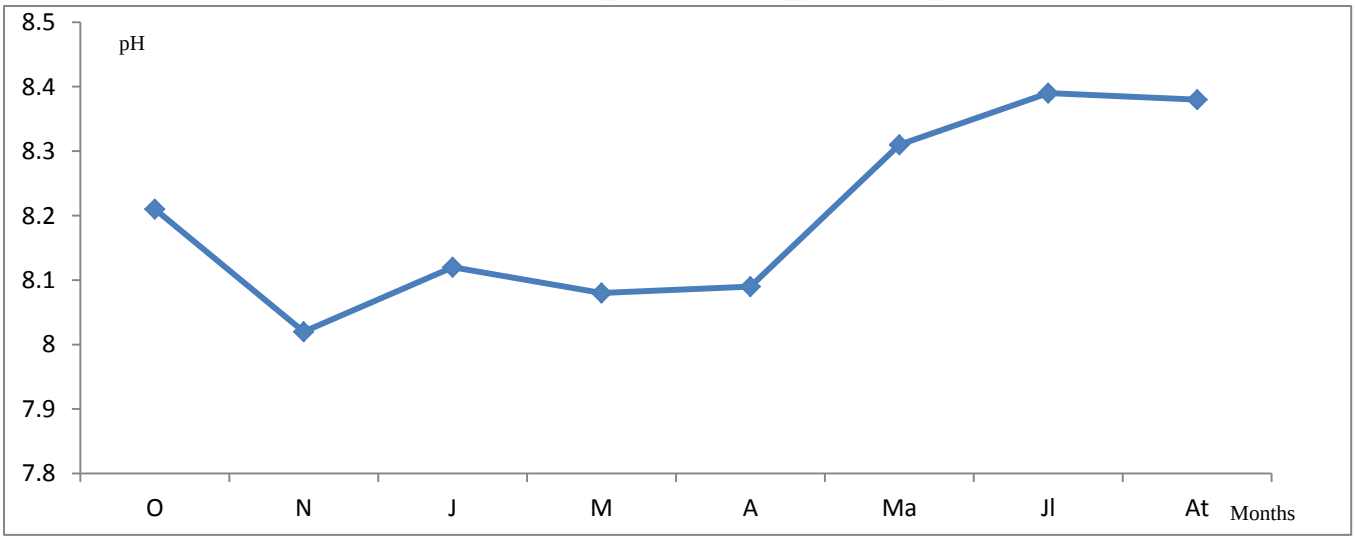

Figure 3: Spatiotemporal Variation of the ph in the waters of Tadout during the year 2015-2016.

- **Electric conductivity (EC):**

Electrical conductivity (EC) is a good indicator of the mineralization of water. Thus, more water is rich in ionized mineral salts, more the conductivity is higher[**22**] **.** The results show little variation between the dry and the wet periods. (**Figure 4**) Recorded values range between 635 (µs/cm) and 665 (µs/cm). These results are far less than those found by [**23**]

in their prospections of sources belonging to the same geological units as those that are the subject of this study. The average recorded is around 651 (µs / cm). Moreover, the comparison of the conductivity values recorded at this source with the Moroccan standard set at 2700 (µs / cm) places the waters of this resurgence in the excellent grid.

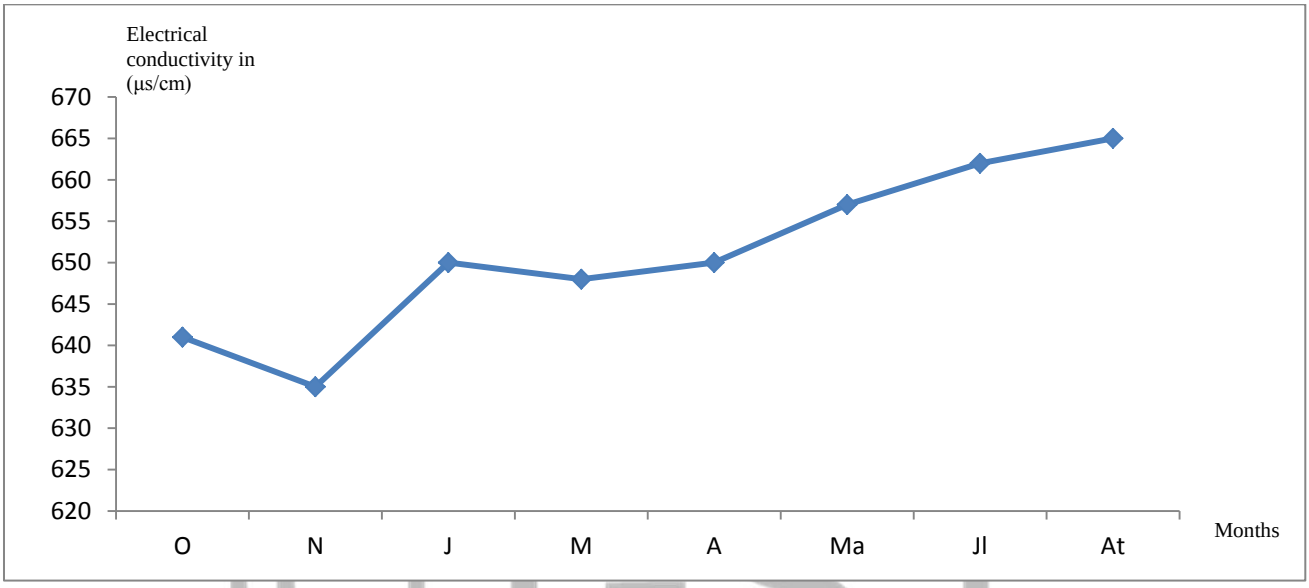

Figure 4 : Spatiotemporal Variation of electrical conductivity in (µs/cm) of waters of Tadout during the year 2015-2016.

- **Chlorides**

Chlorides are important inorganic anions contained in variable concentrations in natural waters, usually in the form of salts (NaCl) sodium and potassium (KCl) [**24**]. These compounds are often used as a pollution index[**25**] . The chloride contents of the analyzed water samples (**Figure 5**) evolve in the same way as the conductivity for the source in

question. The concentrations measured ranged from 19.5 (mg / l) to 33.7 (mg / l).

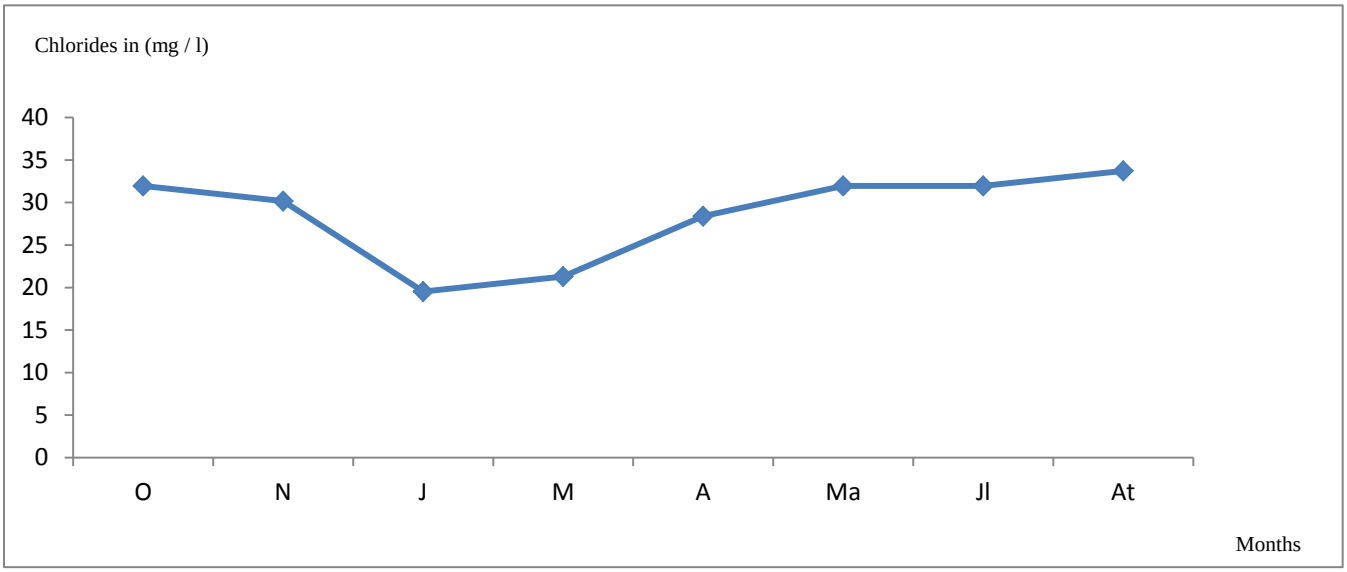

Figure 5 : Spatio-Temporal Variation of Chlorides in (mg / l) of the waters of Tadout during the year 2015-2016

- **Magnesium hardness**

The majority of natural waters contain usually a small amount of magnesium, its content depends on the composition of the encountered sedimentary rocks. This compound comes from the carbonic acid attack of magnesium rocks and the solution of magnesium in the form of carbonates and bicarbonates [**25**]**.** Magnesium levels registered in Tadout range from 22.8 mg/l 15.6 mg/l(**Figure 6**). These relatively high magnesium values could be due to the contact of the water of the source in question with the limestone and dolomitic rocks constituting the aquifer of this study area.

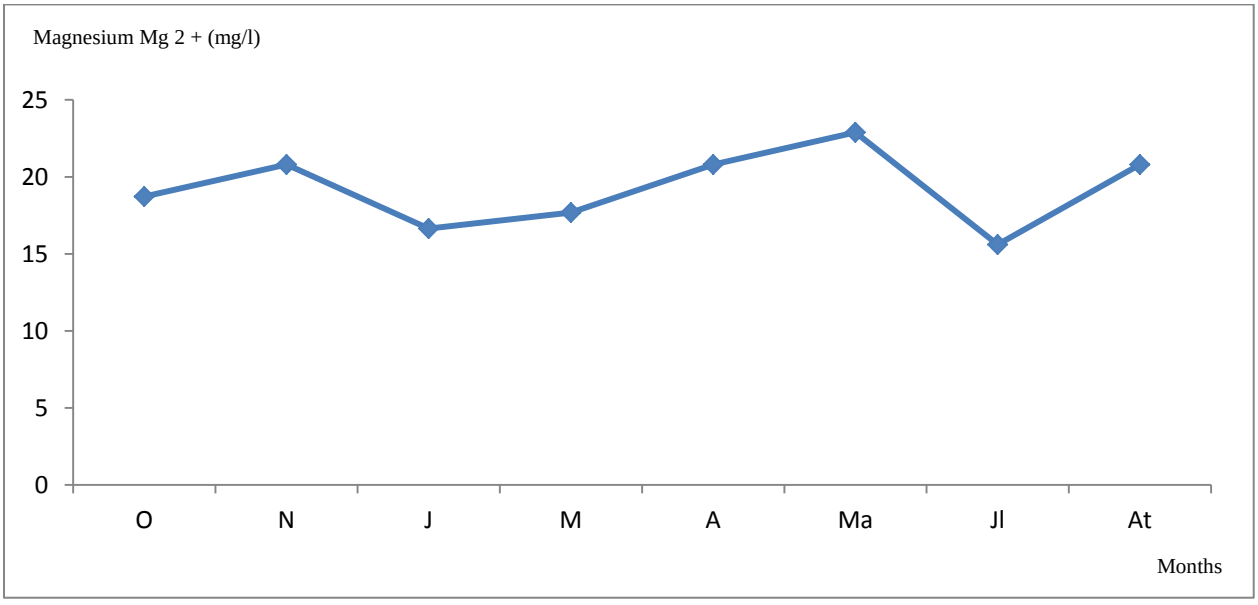

Figure 6: Spatio-temporal Variation of Magnesium Mg 2 + (mg/l) of the waters of Tadout during the year 2015-2016

- **Calcium hardness**

Calcium is usually the dominant element of drinking water and its content varies essentially according to the nature of the crossed lands (calcareous or gypseous ground) [**26**]. The calcium contents of the controlled waters (**Figure7**) ranged from 118.5 mg / l to 144.5 mg / l. The recorded values do not show any notable variations. This seems to be related to the importance of the karst reservoir from which springs the source Tadout.

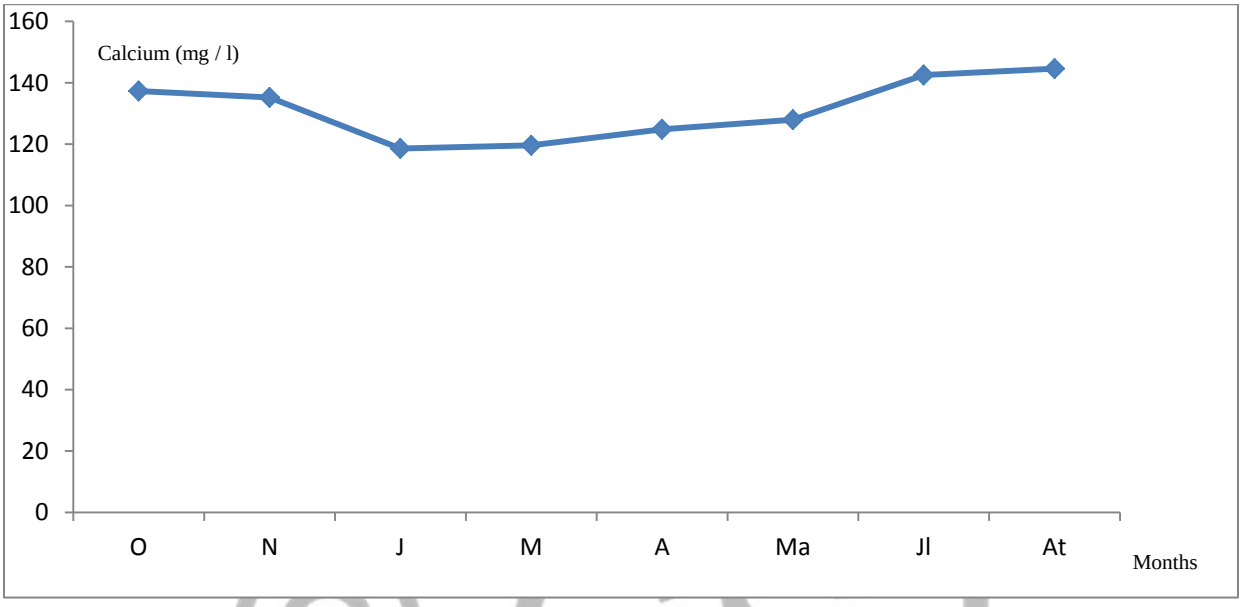

Figure7: Spatio-temporal variation of calcium Ca2 + (mg / l) of the waters of Tadout during the year 2015-2016.

Sulphates

Sulphates are natural compounds of water. Their anthropogenic origins are the combustion of coal and oil which causes a significant production of sulphides (which can be found in the rain), as well as the use of chemical fertilizer and laundry [**26**] Their concentration in water is generally between 2.2 mg / l and 58 mg / l [**19**]. The sulphate contents of the water of the source in question exhibit values ranging from 17.2 mg / l to 31.5 mg / l (**Figure8**). This shows that the waters in question comply with the standards in force **[28].**

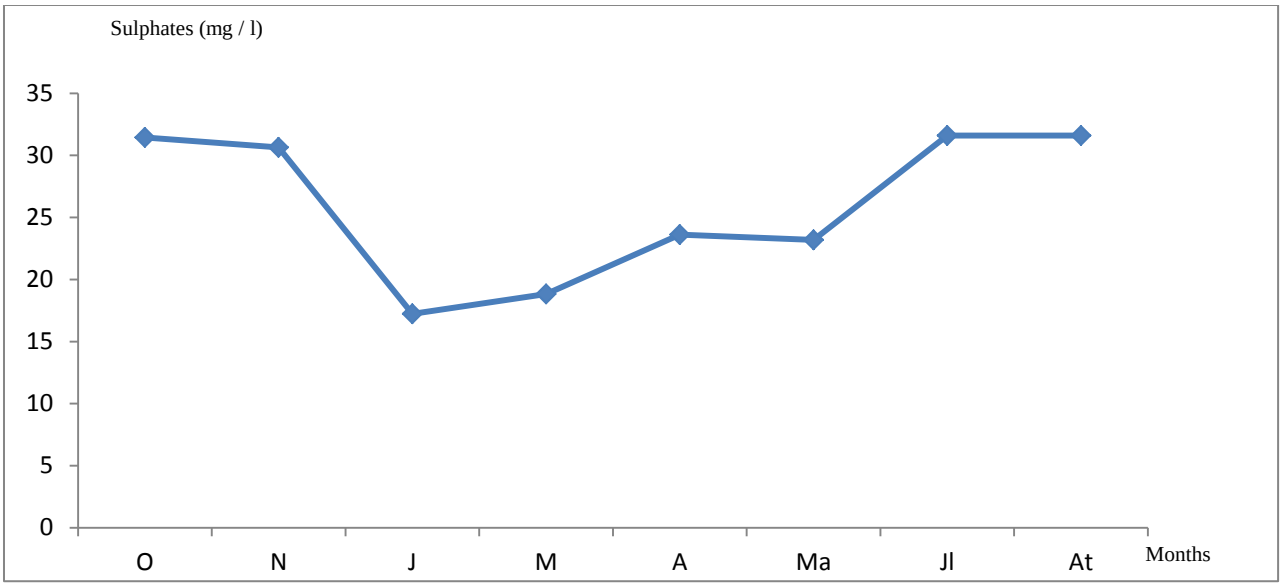

Figure 8: Spatio-temporal variation of sulphates in (mg / l) of the waters of Tadout during the year 2015-2016.

- **Orthophosphates**

Surface waters generally contain phosphates. **[19]** estimate that the natural water content of PO43- is less than 0.025 mg / l and depends mainly on the nature of the geological substratum. In the study station, the concentrations in this element exhibit very low levels not exceeding 0.0068µg / l **(Figure9)**. This value is the maximum recorded in the station during the summer given the increased anthropogenic activity in this period of the year. Furthermore, orthophosphates levels recorded at the source in question remain well below the tolerable threshold which is 0.4 (mg/l). **[23]** and [**24]** also found low levels of orthophosphate and less than 0.5 mg / L during their exploration of the same area studied in this work.

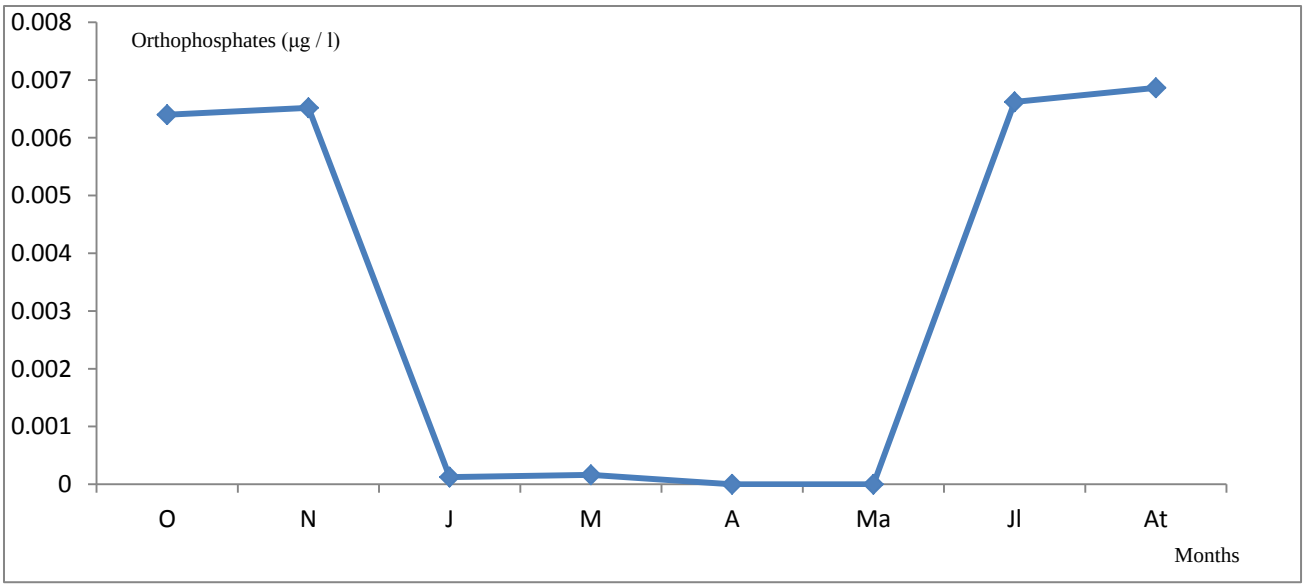

Figure 9 : Spatio-temporal variation of Orthophosphate in (µg / l) of the waters of Tadout during the year 2015-2016.

-Complete Alkalimetric Title (CAT)

The complete alkalimetric titre (TAC) in the water samples analyzed is mainly due to the presence of bicarbonate ions (HCO3), it is the index of the buffer power of water, It is closely related to the hardness, it is closely related to hardness, although many solute species may contribute to it. Alkalinity is expressed in equivalent quantities of carbonates. The temporal evolution of this parameter **(Figure 10)** is sawtooth marked by slight fluctuations both in rainy and dry season, its value varies between 4.22 (meq / l) and 4.60 (meq / l). These values describe a temporal profile similar to that recorded in 2013 at the sources: Tataw, Sidi Bouali and Regrag located in the same area of our study[**11**]. Moreover, the evolution of the alkalinity of the waters of the source in question proves a dissolution of the carbonate rocks in the karst reservoirs.

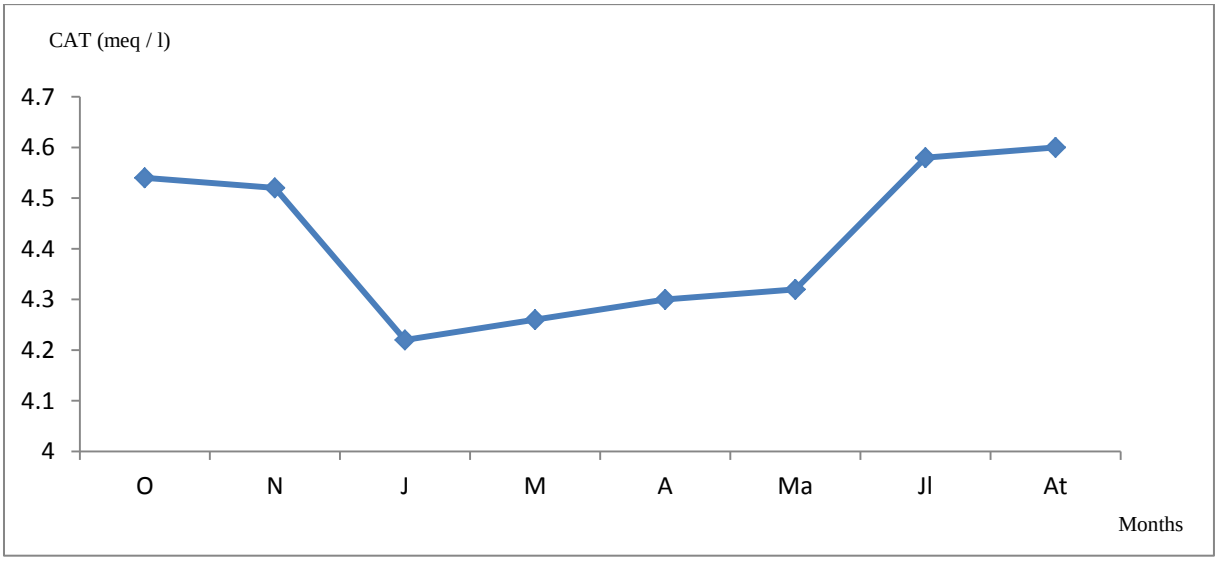

Figure 10 : Spatiotemporal variation of the CAT in (meq / l) of the waters of Tadout during the year 2015-2016.

- **Dissolved oxygen**

The concentrations of dissolved oxygen (dissolved O2) are one of the most important parameters of water quality insofar as they provide information on the degree of pollution of water. The concentration of dissolved oxygen depends on many factors such as temperature. The results of the analysis show that the waters of Tadout are well oxygenated during the year of the study (**Figure11**). The maximum value recorded is 8.83 mg / l marking the winter. This is mainly due to the decrease of the temperature of the water; because cold water contains a lot of dissolved oxygen than hot water[**29**] **.** The average value for this element is established around 7.91 mg/l. This average figure recorded at Tadout does not differ from the values found by **[11**] during their exploration of the same area of our study. Similarly, it should be noted that the results obtained made it possible to classify the waters of this resurgence in the excellent grid[**30**].

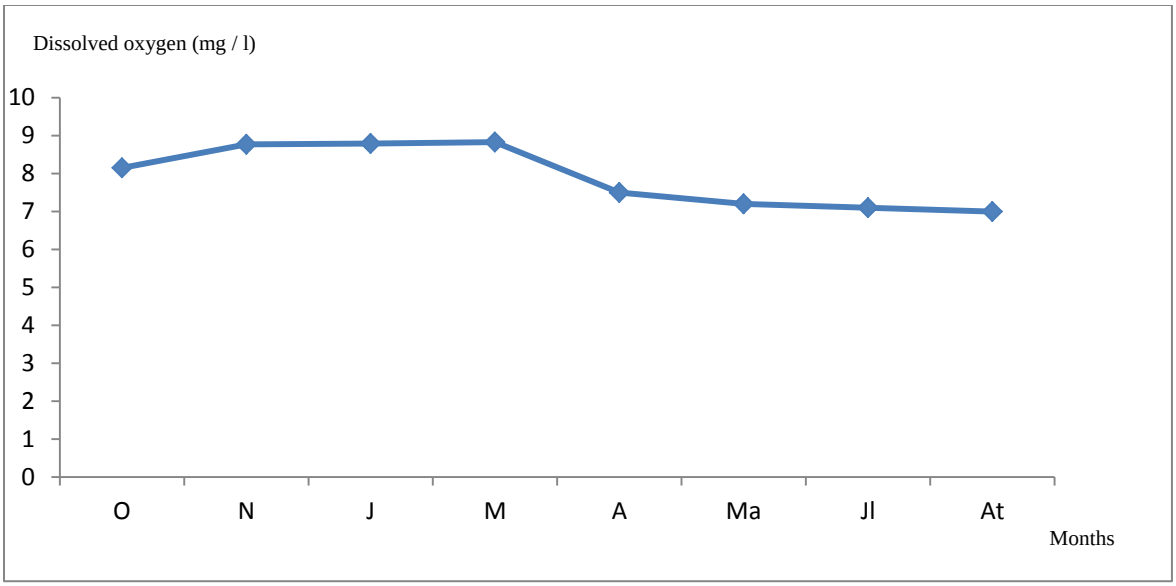

Figure 11: Spatiotemporal variation of dissolved oxygen in (mg / l) of Tadout during the year 2015-2016.

- **Permanganate Index (PI)**

Permanganate Index is one of the important physicochemical factors affecting life in the aquatic environment, It informs us about the concentration of organic matter present in surface and drinking waters. The levels of IP at the studied source fluctuate between 3.16 (mg / l) and 5.71 (mg / l) (**Figure12**). The minimum value recorded marks the winter. This would be due to the vagaries of climate, characterizing the year of study. Indeed, drought that has marked the year of the study has led to an increase in the organic load to the levels of the resurgence in question. Moreover, it can not be omitted to say that the source in question constitutes a seaside resort. Thus, this could be the origin of the increase in the permanganate index especially in the summer period.

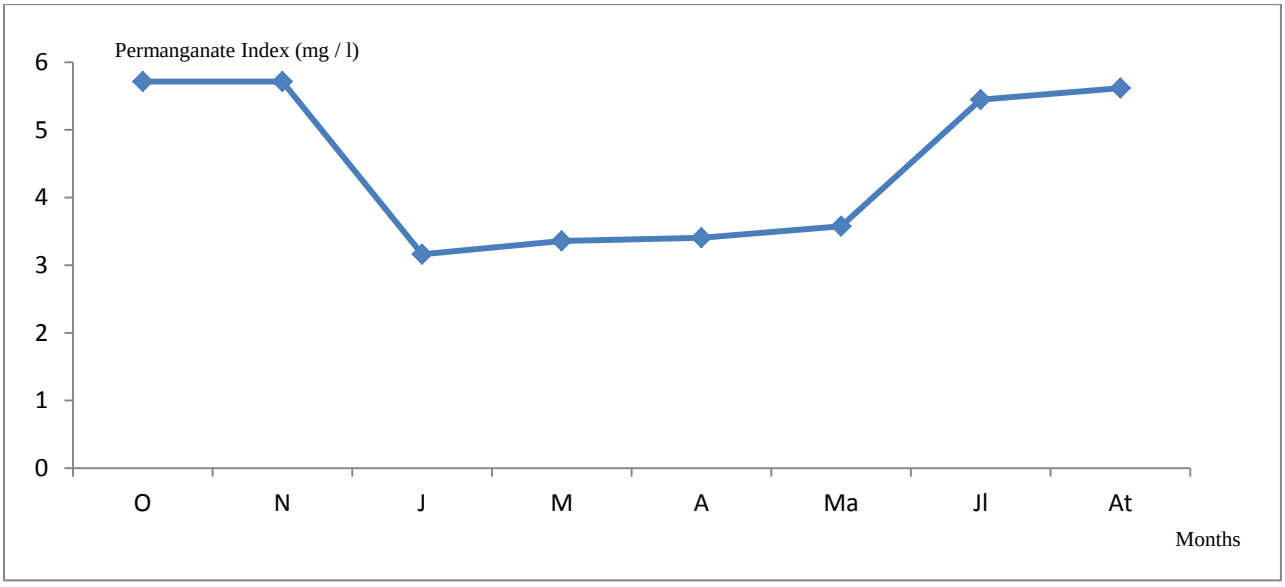

Figure12: Spatio-temporal variation of the permanganate index in (mg / l) of Tadout during the year 2015-2016.

2- Bacteriological analyzes

Results of microbiological analyses are reported in **table 3**.

Table 3 : Results of microbiological analyses of the waters of Tadout

	TAMF(UFC/100ml)	TC (UFC/100ml)	FC (UFC/100ml)	FS(UFC/100ml)
Tadout	100	4650	9000	49

-**Total Aerobic Mesophilic Flora(TAMF)**

The total aerobic mesophilic flora is a health indicator that can be used to evaluate the number of CFUs (Colony Forming Units) present in a product or on a surface. They may be pathogenic microorganisms or alteration microorganisms[**31**]. Concerning the source in question, the rate of these microorganisms is 100 (CFU / 100ml). The recorded values are well above the threshold set by the regulatory framework of surface waters (10 cfu / 100ml). This assumes a risk to consumers of these waters.

-Total coliforms(TC)

Total coliforms are bacteria used as indicators of the microbiological quality of water. Their presence in excess in the water, either 10 coliforms per 100 ml and more, announces a contamination of drinking water**[32]. ** The enumeration of total coliforms in the waters of Tadout reveals a concentration of 4650 UFC/ml. These values reveal clearly faecal contamination of this aquatic ecosystem.

-Fecal Coliforms(FC)

Fecal coliforms, also called thermotolerant coliforms are a subgroup of the total coliforms which is found predominantly in the faeces of humans and animals. Their presence in the water reveals a recent contamination by fecal material and the possible presence of potentially pathogenic bacteria, viruses and protozoa. Bacteriological evaluation of the samples of our sample point indicates the presence of CF at a rate of 9000 UFC / 100ml. According to the regulatory framework of the waters of surfaces in CF, the waters of the Tadout source are classified among the waters of poor quality (> 20000 UFC / 100ml).

-Fecal streptococcus(FS)

This type of bacteria can lead to serious health problems. It is mainly related to faecal contamination. Some fecal streptococci can be transformed into initiating germs of several diseases such as angina and meningitis. Research of fecal streptococci in the water sample taken from the waters of the source Tadout has revealed their presence at a rate of 49 UFC 100 ml. This value, largely above the threshold of 0 cfu / 100 ml set by [**28**] shows probably a

fecal water contamination of the aquatic ecosystem in question as well as a significant pathogenic risk.

3- Benthic macrofauna

3.1- Inventory of the benthic community

One of the major objectives of the seasonal monitoring of Macroinvertebrates living in the source Tadout is a complete inventory of different taxa surviving in this aquatic ecosystem. The analysis of the taxonomic composition of the species found in Tadout revealed the presence of 27 species of macroinvertebrae divided into 8 classes, 14 orders, 17 families and 22 genera. The list of species collected at this source as well as their spatio-temporal evolution are respectively exposed in tables **4** and **5**.

Table 4: The faunistic list of the study station during the year 2015-2016

Phylum	Class	Order	Family	species
Molluscs	Gastropods	Caenogastropoda	Melanopsidae	***Mélanopsis praemorsa***
		Néotaenioglosses	Hydrobiidae	***Corosella sp.***
				Horatia sp.
				Pseudomnicola sp.
		Neritimorpha	Neritidae	***Thiodoxus numidicus***
Annelids	Achaetes	Rhynchobdellida	Glossiphonidae	***Helobdella sp.***
	Oligochaetes	Lumbriculida	Lumbriculidae	***Lumbricus sp.***
Plathelminthes	Turbellaria	Triclads	Planaridae	***Phagocata sp.***
Arthropods	Malacostraca	Amphipoda	Gammaridae	***Gammarus rifatlensis***
				Gammarus marocannus
	Ostracods	Myodocopida	Cypridinidae	***Cypridopsis sp.***
				Cypridina sp.
	Insects	Diptera	Ceratopogonidae	***Dasyheleina sp.***
			Dixidae	***Dixa sp.***
			Simulidae	***Simulium wilhemia***
				Simulium sergenti
		Heteroptera	Gerridae	***Gerris sp.***
		Ephemeroptera	Baetidae	***Baetis rhodani***
				Baetis pavidus
			Caeinidae	***Caenis luctuosa***

			Héptagenidae	***Héptagenia sp.***
				Ecdyonurus ifranensis
		Coleoptera	Elmidae	***Liminus sp.***
		Trichoptera		***Oxyethira sp.***
			Hydroptilidae	***Hydropsyche sp.***
	Arachnids	Hydracariens	Pontarachnidae	***Hydrachnidia sp.***
			Pionidae	***Piona uncata***

Table 5: Seasonal changes in the abundance of benthic macrofauna in Tadout during the year 2015-2016

Species	0-2015	N-2015	J-2016	M-2016	A-2016	Ma-2016	Jl-2016	At-2016
Melanopsis praemorsa	25	20	16	26	33	25	28	30
Pseudomnicola sp.	1	2	4	5	7	6	5	7
Corosella sp.	8	3	-	4	6	7	8	10
Horatia sp.	9	6	8	10	12	11	10	12
Thiodoxus numidicus	17	15	10	17	22	23	26	28
Helobdella sp.	10	2	2	5	11	7	9	11
Lumbricus sp.	5	8	3	4	6	5	4	6
Phagocata sp.	15	16	8	10	14	15	17	19
Gammarus rifatlensis	58	56	50	51	53	55	57	60
Gammarus marocannus	31	34	24	26	28	30	32	35
Cypridina sp.	3	-	3	4	5	3	2	4
Dasyheleina sp.	3	1	3	4	0	1	2	4
Dixa sp.	9	8	5	4	6	8	10	12

Simulium wilhemia	3	2	2	1	3	-	2	4
Simulium sergenti	4	1	1	-	5	4	3	6
Gerris sp.	1	-	-	-	2	3	5	4
Baetis rhodani	19	15	7	11	16	17	19	21
Baetis pavidus	12	13	8	5	7	10	13	15
Caenis luctuosa	1	5	2	-	4	3	2	3
Héptagenia sp.	3	1	-	2	5	3	2	4
Ecdyonurus ifranensis	7	5	2	4	5	6	8	10
Liminus sp.	3	-	-	2	3	4	4	5
Oxyethira sp.	4	3	-	1	3	5	3	5
Hydropsyche sp.	8	5	-	2	3	5	9	11
Hydrachnidia sp.	2	-	-	1	3	2	1	3
Piona uncata	-	-	-	-	-	1	-	-

- : Absence

-Total abundance

The analysis of all collected taxa during the study period, revealed that Arthropods are numerically the most inventoried and represent the highest percentage at Tadout (63.03%) followed successively by the molluscs (26.3%), the Platyhelminths (5.77%) and finally the annelids which are the least inventoried (4.9%) **(figure 13).**

For comparative purposes, the number of taxa cllected from Tadout is significantly less diversified compared with those found by [**23**] in the Tataw source which belongs to the same geological entity as our study station. This could be related to natural and / or anthropogenic factors influencing this aquatic ecosystem. Indeed, drought that hit during our study period, as well as organic pollution of anthropogenic origin could, probably contribute greatly to the installation of particular conditions (generally unfavorable) to the presence of a very diversified stand, characteristic of this source.

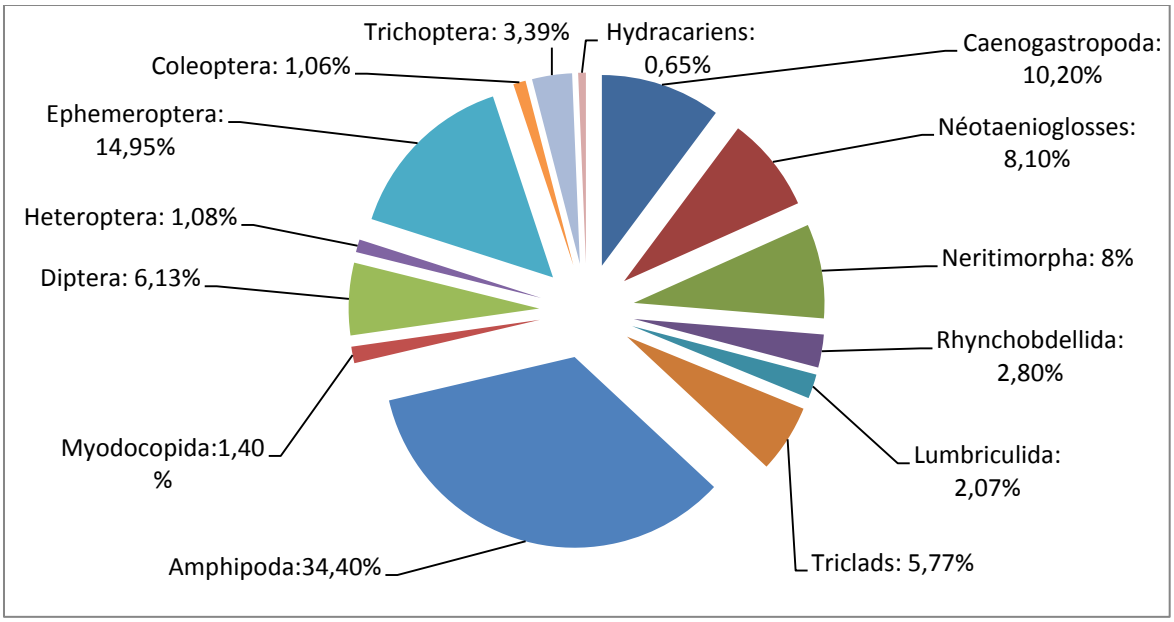

Figure 13: Abundance of the global fauna in the waters of the studied station during the year 2015-2016

- **Specific diversity index**

Species diversity can be defined as a measure of species composition of an ecosystem, in terms of number of species and their relative abundance[**23**].

The source Tadout is marked by a low diversity index, it is of 0,338. Drought and anthropogenic action strongly influenced the diversity of this station resulting in its deterioration. Indeed, the disruption of aquatic ecosystem has fostered the proliferation of polluo-tolerant taxa such as Gammarus pseudoronticulus which is the dominant species in this source (22.3%) and the low abandance of polluo-sensitive species such as Corosella sp **(Figure 14)** without omitting to say that some taxa have been completely extinct such as the plecoptera found by [17]during their prospection of the same source during the year 1984.

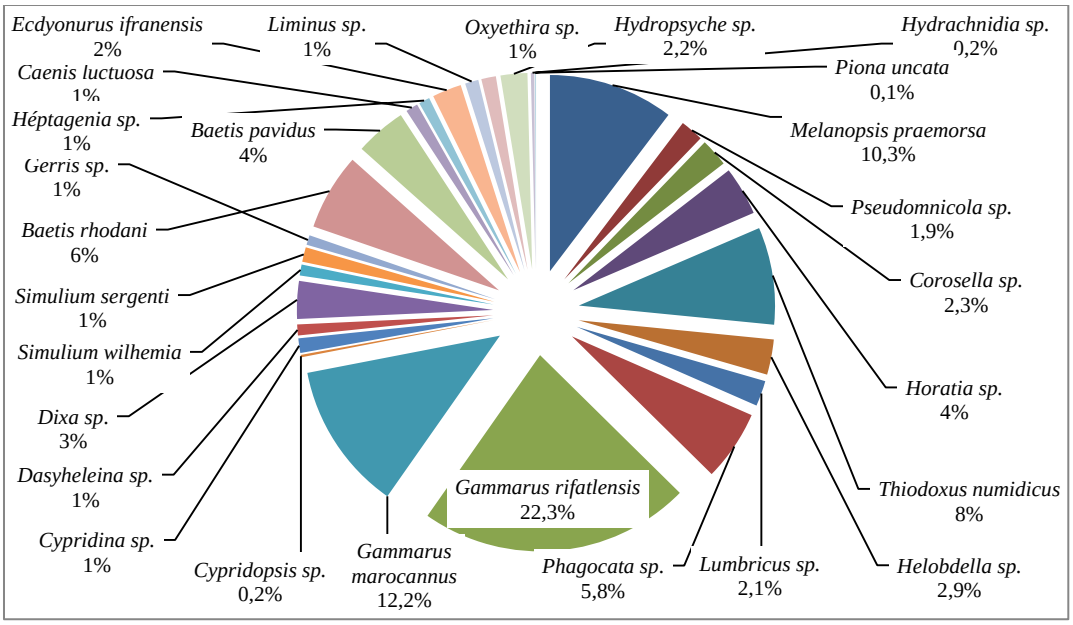

Figure 14: Relative abundance of different taxa identified in the source tadout

- **Index of specific fairness**

The Index of specific fairness measures the distribution of individuals within species, regardless of species richness. Its value varies from 0 (dominance of one of the species) to 1 (evenly spread numbers of individuals within species). In the study station, this index is low, it is of the order of 0.071. This result proves that the listed species do not have the same abundance.

- **Frequency**

Constant species that confined permanently the source Tadout represent over three quarter (76%) of the benthic fauna total. This result is consistent with the one found by [**23**] when they searched for a source belonging to the same geological entity as our study station. Besides these constant species, we have found two species accessories (**Table6**).

Table 6: Frequency of occurrence of the species colonizing the Tadout source

Species	Frequency%	Presence
Melanopsis praemorsa	100	
Pseudomnicola sp.	100	
Corosella sp.	87,5	
Horatia sp.	100	
Thiodoxus numidicus	100	
Helobdella sp.	100	
Lumbricus sp.	100	Constant
Phagocata sp.	100	(≥50%)
Gammarus rifatlensis	100	

Gammarus marocannus	100	
Cypridina sp.	87,5	
Dasyheleina sp.	87,5	
Dixa sp.	100	
Simulium wilhemia	87,5	
Simulium sergenti	87,5	
Gerris sp.	62,5	
Baetis rhodani	100	
Baetis pavidus	100	
Caenis luctuosa	87,5	
Héptagenia sp.	87,5	
Ecdyonurus ifranensis	100	
Liminus sp.	75	
Oxyethira sp.	87,5	
Hydropsyche sp.	87,5	
Hydrachnidia sp.	75	
Piona uncata	12,5	50<accessory<25
Cypridopsis sp.	25	

Conclusion

Biodiversity and freshwater habitats are recognized as particularly threatened at global level. Monitoring of freshwater basins is proving so be a necessary measure to prevent the loss of these ecosystems. As a result, monitoring of the hydrobiological quality of aquatic ecosystems is necessary. Hydrobiological study of the source Tadout allowed us to identify the State of ecological health of this aquatic ecosystem. Indeed, the physicochemical analysis of the source Tadout has shown that the waters of this aquatic ecosystem are cold, miniralised, hard and affected by an organic pollution. However, the values found are lower than the permissible limits of [**28**] **.** Concerning microbiological assessments, the results were high and exceeding standards values fixed by the regulatory framework of surface water.

The fauna inventory completed in the present study constitutes a first database updated and complete of the Tadout source. The fauna collected from this aquatic ecosystem revels the presence of 1973 individuals grouped in 27 species belonging to 17 families and 22 genera.This ecosystem is mostly dominated by the Arthropods (63, 03%), followed by the Molluscs (26,3%) and finally the annelids which are the least inventoried (4.9%). in addition, The results revealed that the source in question is marked by a low diversity index and specific fairness. therefore measures to safeguard this aquatic ecosystem are needed.

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References

[1]**Dakki. M**., 1979. Recherches hydrobiologiques sur lin cours d'eau du moyen Atlas (Maroc). Thèse de 3ème cycle, Aix Marseille lI/, 126 p.

[2]**Dakki M.,** 1986. Recherches hydrobiologiques sur le haut Sebou (Moyen Atlas) ; une contribution à la connaissance faunistique, écologique et historique des eaux courantes sud-méditerranéennes. Thèse Doctorat d'Etat, Univ. Mohammed V, Fac. Sci., Rabat, 181 p

[3]**Dakki M.,** 1987. Ecosystèmes d'eau courante du haut Sebou (Moyen Atlas) ; Etudes typologiques et analyses écologiques et biogéographie des principaux peuplements entomologiques. Trav. Inst. Sci., Serie Zoologie, 42, 99 p

[4]**Badri M.A**., 1984. in proc.Nat.Symp. on research and development in physical and applied sciences, Bangi, Selangor,Malysia, Sep 18-20,1984(in Maly ;in press).

[5]**EL AGBANI M.A.,** 1984. Le réseau hydrographique du bassin versant de l'Oued Bou Regreg (Plateau Central marocain). Essai de biotypologie. Thèse de 3e cycle, Univ. Claude-Bernard, Lyon 1, 14'ï p.

[6]**El Alami E.M.,** 1989. Etude hydrobiologique d'un reseau hydrographique nord-rifain, l'oued laou : typologie, écologie et biogéographie des ephemeropteres.Thèse doc.3eme cycle, Fac. Sci, Rabat, 183pp.

[7]**Taoub H.,** 1989. Etude hydrobiologique rifain, l'oued laou : Typologie et ecologie des trichoptères.Thèse doc.3eme cycle.Fac.Sci.Rabat, 137pp.

[8]**HIMMI O**., 1991. Culicidae (Diptera) du Maroc : Clé de détermination actualisée et étude de la dynamique et des cycles biologiques de quelques populations de la région de Rabat-Kénitra. Thèse doct. 3ème cycle, Fac. Sci. Rabat : 185 p.

[9]**Berrahou A.,** 1995. Recherches sur la distribution longitudinale des macroinvertébrés benthiques : cas du Rhône français et des cours d'eau marocains. Thèse Doctorat d'Etat, Univ. Mohammed I, Fac. Sci., Oujda, 212 p.

[10]**FADIL F** and **DAKKI M**., 2006. Deux espèces nouvelles du genre Gammarus (Crustacés, Amphipodes) du Maroc. Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, n°28, 13-24.

[11]**Nechad I., Fadil M and Fadil F.,**2014. Regard Sur L'etat Physicochmique Et Bacteriologique De Trois Grandes Sources Au Moyen Atlas (Maroc)

[12]**AFNOR**., 1997. Qualité de l'eau. Recueil des Normes Françaises Environnement, Tomes 1, 2, 3 et 4, p1372

[13] **Chambon. H., Champsaur A., Rodi L., 1996.** L'analyse de l'eau. 8 ème édition, Edition Dunod, Paris, France.

[14] **De Pauw and Vanhooren.,** 1983. Dossiers Stichting Leefmilieu 11: Macroinvertebrates and water quality. Stichting Leefmilieu, Antwerp.

[15] **Tachet H., RICHOUX P., BournaudM** and **Usseglio-Polatera P**., 2006. Invertebrés d'Eau Douce (2nd corrected impression). CNRS editions. Paris. France. 588 pp.

[16] **Leynaud G.,** 1968., Les pollutions thermiques, influence de la température sur la vie aquatique. B.T.I. Ministère de l'agriculture, 224-881.

[17] **Giudicelli J** and **Dakki M**., 1984. The larva and female of Rhyacophila fonticola (Trichoptera: Rhyacophilidae), an interesting Betic–Rifean endemic species.

[18] **Schoeller H**., 1955-1956 : Géochimie des Eaux souterraines. Application aux eaux des gisements de pétrole. Revue de i'Institut Fr. du Pétrole et Ami. des combustibles liquides, n° mars, avril, juin, juillet, août 1955 et I vol. 213 p. Ed. Tcchniq, Paris.

[19] **Meybeck M., Fridrich G., Thomas R and Chapman D.,** 1996. Rivers.Waterqualityassessments : a guide to the use of biota, sediments and water in environment monitoring, Chapman edition, 2nd ed. E & FN Spon,London, pp. 59-126.

[20] **Nechad I , Fadil K and Fadil F**.,2014. Contribution à l'étude du cycle de reproduction de Gammarus marmouchensis Fadil, (Crustacés, Amphipodes) dans la source Tataw (Moyen Atlas, Maroc)

[21] **MINISTERE DE L'ENERGIE, DES MINES, DE L'EAU ET DE L'ENVIRONNEMENT.,** 2007. Maroc

[22] **Derwich E., Benaabidate L., Zian A., Sadki O., Belghity D.,** 2010. Larhyss Journal, 08 -101-112.

[23] **Nechad I** and **Fadil F.,** 2016. Taxonomic diversity of benthic stands of the Tataw source(ImouzerMarmoucha,Middle Atlas - Morocco)

[24] **Karrouch L** and **Chahlaoui A**., 2005., Bio-evaluation de la qualité des eaux de l'oued boufkrane(Meknes, Maroc).

[25] **Nouayti N., Khattach D., Hilali M.,** 2015 .Evaluation de la qualité physico-chimique des eaux souterraines des nappes du Jurassique du haut bassin de Ziz (Haut Atlas central, Maroc) Assessment ofphysico-chemical quality of groundwaterof the Jurassic aquifers inhigh basin of Ziz (Central High Atlas, Morocco). J. Mater. Environ. Sci. 6 (4) 1068-1081 . ISSN : 2028-2508 CODEN: JMESCN

[26] **Rodier J.,**2009. L'analyse de l'eau, 9e édition. DUNOD (éditeur), Paris, France.

[27] **BARRY G.S.,** 1989. Sodium sulphate. Canadian mineralsyearbook – 1988.Mineral Resport, n° 37. Division des ressources minérales, énergie, mines etressources. Ottawa

[28] **NM 03.07.001.,** 2006 . Normes marocaines Eaux-Aliments; Eaux d'alimentation Humaines-qualité des eaux d'alimentation Humaine.

[29] **HÉBERT S. et LÉGARÉS.,** 2001. Suivi de la qualité des rivières et petits cours d'eau, Québec" Envirodoq no ENV-2001-0141,rapport no QE-123, 24. p. annexe 3.

[30]**Ministere de l'energie, des mines, de l'eau de l'environnement, Maroc.,** 2007.

[31]**Bougeois C.M** and **Leveau J**., 1996.Teclmique d'analyse et de contrôle dans les industries agroalimentaires.Paris:Lavoisier TEC et DOC, ,331 p.

[32]**Agence de la santé et des services sociaux de Chaudière-Appalaches**., 2011.

HIMMI O., **TRARI B.**, **Mohammed A., El Agbani and Dakki M**., 1997. Contribution à la connaissance de la cinétique et des cycles biologiques des Moustiques (Diptera, Culicidae) dans la région de Rabat-Kénitra (Maroc).

Abdoulaye D.N., **KhadijettouMint M.S.**, **El Kory M.B.**,**Ould Side M.,OuldKankou A., Baudu M**., 2014. Contribution à l'étude de l'évolution Spatio-temporelle de la qualité physicochimique de l'Eau de la Rive droite du fleuve Sénégal, J. Mater. Environ. Sci. 5 (1) 320-329.

Agence de la santé et des services sociaux de Chaudière-Appalaches., 2011. Quoi faire si la quantité de coliformes totaux ou de bactéries atypiques dans l'eau de votre puits dépasse la norme?

.

El Agbani M.A and Dakki M. 2005. Importance ornithologique du complexe des zones humides de la région de Smir. In : Bayed A. & Scapini F. (eds) - Ecosystèmes côtiers sensibles de la Méditerranée: cas du littoral de Smir. Trav. Inst. Sci., Rabat, série Générale, 4, pp. 61-64.

Kettani K., Vilchez A., Calle D. and El Ouazzani T., 1994. Les Chironomidés (Diptera) de l'Oued Laou (Versant méditerranéen du Rif, Maroc). Ann. Limnol, 30 (1) : 25-32.

Meybeck M., Kuusisto E., Makela A and **Malkki E. 1996.** A pratical guide to the design and implementation of fresh water quality studies and monitoring programme." E&F.N.

Ministere de l'energie, des mines, de l'eau et de l'environnement, Maroc ., 2007. Normes de qualité. Eaux destinées à l'irrigation.

Naya.S.,1988.Trade and Trade Policies.In challenge of Asian developing contries : Issues and Analyses, edited by S.Ichimura chap3.Tokyo :Asian Productivity Organisation.

Pieresma Tand Ramdani M., 1984. Semi benthinish levende mollusken in an brakke sloot bi ji Sadi Moussa Nd : Mal ver.216,1450-1954.

Thomas and **Mohadi**.,1985. Rlithrogena ourika. Annls limnol21(2) :145