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An Evaluation System of Surface Water Quality in Algeria (Application on the Western Algerian Catchements)

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ABSTRACT
Easily accessible surface waters remain very fragile and very vulnerable to various types of pollution. Chellif, Macta and Tafna Basins are considered as the main water resources feeding the North West of Algeria; however, protection and conservation of these water resources become the major concern of the researchers. The evaluation system of the water quality is based on the measure of physic-chemical parameters of the surface water according to the uses of water for drink, industry or agriculture. In this work we have to proceed to an application of this system to the surface waters on the three basins. Physic-chemical analyses are used for a period of three years (2012-2014) and several points chosen on the three catchments are taken into account.
In this paper we shall apply the quality index calculation method for the Water Quality Evaluation system (WQES) and the follow-up of the impacts of the anthropologic activities on the natural environment The main results are the validation of the WQES method for different type of pollution as mineral, organic, heavy metals in the West of Algeria, this methodology give us possibility for better investigation of the water pollution.
Keys words: Water quality, Physic-chemical parameters, uses of water, quality grid.

I. INTRODUCTION

Due to the water shortage and the population growth; the amount of fresh water is limited in Algeria and very vulnerable to various types of pollution [1; 2]. In response to the current deficiencies concerning water resources: protection; management and all known pollution risks (uncontrolled urban and industrial wastewater releases) of this rare commodity are required.
In this paper; the adoption of a single methodology of the Water Quality Evaluation System (WQES) for water surface [3] is going to allow us to appreciate better the quality of waters and especially estimate the pollution; it is going to lead us to a better management of the water resource according to the use in which it will be intended [4].

The WQES is based on the measure of physic-chemical parameters of the surface water and the follow-up of the impacts of the anthropologic activities on the natural environment [5, 6]. It is a part of river quality assessment that aims to convert the chemical data of water quality to simple information which is more suitable. It is often based on an estimation of the quality with comparison to the grid conceived according to the uses of the water: drinkable, industrial, agricultural waters and leisure activities. This conception is on the basis of all systems of evaluation of water agencies worldwide. It would be more sensible for population to use a water of average quality (class 2 and 3) for domestic uses than wasting water of high chemical quality water [6-9]. Three important catchments Chellif, Macta and Tafna are considered as the main water resources feeding the North West of Algeria are taken as a study area. Physic chemical analyses of 44 sampling stations are used. For a better evaluation; only chemical parameters defining salinity; organic and heavy metals waters alterations are taken into consideration.

II. MATERIALS AND METHODS

2.1 Presentation of the study area

Tafna basin is situated in an extreme western of Algeria, extends over a surface of 7.245 km^2, covering Tlemcen, Maghnia [11-13]; it is limited to the North by the Mediterranean Sea and the high plains of Oran; on the West by the Moroccan average Atlas and in the East by Daya of Sidi-Bel-Abbès Mounts.

Macta basin is situated in North East of Tafna with 14750 km² [14] of surface area Fig.1. It is bounded in the Northwest by the mountain range of the Tessala, in the South by the high plateaus of Ras El ma and Maalif plain, in the East by the trays of the Telagh and the Saïda Mounts and finally on the West by the Tlemcen Mounts which are the

continuations of the Beni Chougrane Mounts. Cheliff is the biggest basin in the region located in the North East of Macta Extending over a surface of 56 227 [15]. Only the western region (26 948 km²) around Relizane Tiaret and Chlef cities will be assessed. In this study, Tafna, Macta and Chellif are chosen for the WQES using calculation Indexes method.

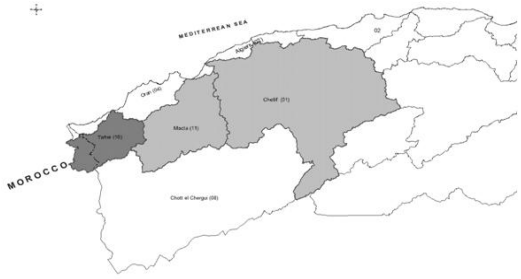

Figure1. Location of the study area

2.2 Sampling and physic-chemical analysis

The sampling was monthly carried out on the network measurement stations of assessment water quality of the NAHR, these station are distributed on all of the long streams of the three basins overturning of Tafna, Macta and Chellif, more than 44 stations has been taken into account during this study, the period of sampling spreads out over a period of 2012-2014, the main chemical parameters cited below "Table1, 2, 3" were assessed [16].

Physic–chemical analyses were realized with the collaboration between NAHR Laboratory and the LSTGP laboratory of University of Science and Technology of Oran Mohamed BOUDIAF. Chemical data [10] used for the Calculation system are for a period (2012-2014). From the net work assessment of the surface water quality of the National Agency of the Hydraulic Resources (NAHR), 44 sampling stations located around the three basins are investigated Fig.2, maps are taken from department of water surface of NAHR [17.

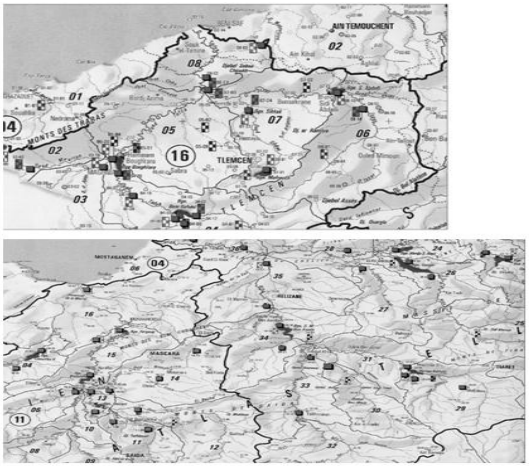

Figure2. Representation map of sampling stations

2.3 Qualities indexes determination

The chemical parameters were grouped together on different families according to the type of pollution, five classes with their values thresholds were used to identify the water quality.

2.3.1 Mineral quality by Salinity Index (Isal)

Salinity Index (Isal) is represented by two major salts: sulfates and chlorides Table 1 as well as global conductivity of the water, these parameters remain sufficient to estimate the salinity of water. The addition of the other salts to specify the alteration of the salinity according to the requirements of a special mineral quality can be proposed.

Table1: Thresholds values of the salinity Index (Isal)

Class	SO_4^{2-}(mg/L)	Cl^- (mg/ L)	Conductivity (µs/cm)
1	≤ 200	≤ 150	≤ 400
3	200 - 300	150 - 300	400 - 750
4	300 - 400	300- 500	750 - 1500
5	> 400	> 500	> 3000

2.3.2 Organic quality Index (Iorg)

Water Organic quality is evaluated by assessing the following parameters: O_2Dissolved (% of saturation), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand on Five days (BOD_5). Ammonia and Total Nitrogen Kjeldahl, limit class for all parameters are presented Table.2.

Table2. Thresholds values of the organic Index (Iorg)

Class	O_2 (% saturation)	BOD_5(mg/L)	COD(mg/L)	NH_4^+(mg/L)	TNK (mg/L)
1	>90	<3	<20	<0,5	≥1
2	90 - 70	3 – 6	20 - 30	0,5 – 1,5	1 – 2
3	70 – 50	6 – 10	30 – 40	1,5 – 4	2 – 6
4	50 – 30	10 – 25	40 – 80	4 – 8	4 – 12
5	≤30	≥25	≥80	≥8	>12

2.3.3 Quality indexes in inorganic toxic elements (Itxm)

Assessment grids fixing the values thresholds of the various quality classes for the inorganic and organic toxic elements were established in Table 3.

The assessment of surface water, especially in this region, nitrates and heavy metals quality indexes are elaborated. Nitrates pollution is not very pronounced, for that only, the three heavy metals are taken into account: Total Chromium, Copper and Mercury.

Table.3 Concentrations class limit in µg/L defining toxic heavy metals Index (Itxm)

Classes	Cr	Cu	Hg
1	≤0.36	≤0.27	≤0.007
2	0.36 – 3.6	0.27- 2.7	0,007- 0.07
3	3.6 -36	2.7 - 27	0.07 -0.7
4	36 -700	27 – 40	0.7 - 3
5	>700	>40	> 3

The classification proposed by categories or classes in this study are as follows:

- Class I (Blue): Excellent, water quality is practically not degraded; conditions are similar to natural water.
- Class II (green): Good quality, water quality is slightly degraded, low pollution.
- Class III (Yellow): medium quality, water quality is occasionally degraded, important pollution.
- Class IV (Orange): poor quality, water quality is often degraded, very important pollution.
- Class V (Red): bad quality, water quality is almost always degraded, high pollution and cannot be used unless treated at high price.

III. RESULTS AND DISCUSSION

The processing of chemical data allowed highlighting the qualitative aspect of superficial resources in the Algerian Northwest.

***T*able.4 Quality indexes determinate by calculation method**

Number of station	Station code	Iorg	Isal	Itx heavy metals	Global Quality Index (GQI)
1	010907	5	4	4	**5**
2	011002	5	5	3	**5**
3	012201	5	5	3	**5**
4	012311	5	5	3	**5**
5	012403	5	5	3	**5**
6	012410	5	5	5	**5**
7	012610	5	5	3	**5**
8	012806	5	5	3	**5**
9	012901	5	4	3	**5**
10	013410	4	5	4	**5**

3.1 Mineral water quality

Mineral Water quality represented by the Salinity index (Isal) showed in Fig.3 is altered by the Conductivity value (>1500 µs/cm). Only dams have a moderate values between 750 and 1500 µs/cm. Only 4.55% of stations measures present a good quality with Isal =1 and 11.36% for Isal=2; salinity index in all the three basins indicate poor quality Isal = 4 for 22.73% of measures and bad quality Isal =5 for 61.36 % of stations. The critical shortage of water in the west of Algeria caused by the irregular precipitation and the high consumption of surface water are the principle mineral alteration.

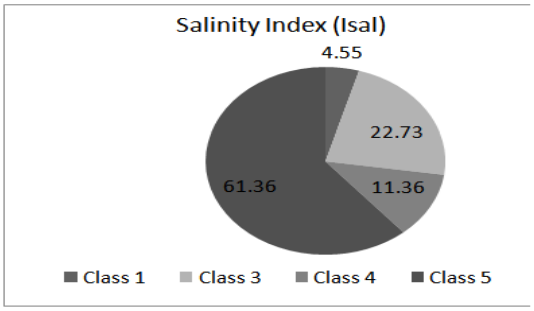

Figure.3 Salinity index distribution

3.2 Organic Water quality

The organic water quality (Iorg) is altered by Ammonia which is one of the most important parameter for assessing pollution. For the registers values in all basins, concentrations of Ammonia are higher than 0,5mg/L; the recommended by the WHO and the Algerian standards [16, 18] also COD and BOD_5 are the declassed parameters for this kind of pollution, the Oxygen dissolved (% saturation) values are decreased to zero.

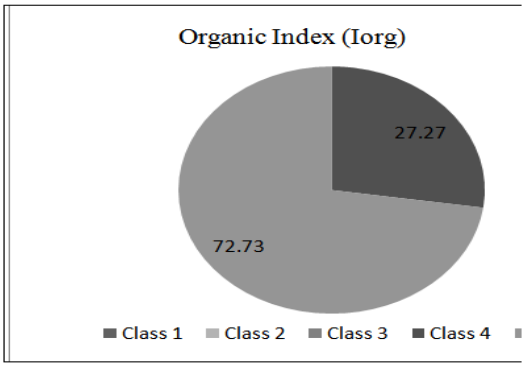

Figure.4 Organic index distribution

0% of measures present an Organic quality index 1, 2 and 3, only 27.27 % have Iorg= 4 and 2.73% of stations have Class 5 or out of range Fig.4. This abundance of organic pollution is related to the human activities, industrial plants, showing organic pollution domination in overall the three basins Fig.5 and particularly the station close to the agglomerations: Tiaret, Mascara, Sidi Bel Abbes, Tlemcen and Maghnia.

We shall quote below consumption of water by different cities in the region.

Table.5 Inventory of the pollution sources

City	Number of industrial	Water consumption volume (m^3/j)	Sewage water volume (m^3/j)
Sidi Bel Abbes	134	6339.39	4240.45
Mascara	82	2637.67	1920.032
Saida	28	5057.38	406.65
Tlemcen	21	9373.90	7499.12

Oueds became natural collectors of urban and industrial discharges draining chemical and toxic elements. Their capacity of cleaning up is more and more reduced, in particular period of low-water mark, where there is no dilution. The data available and applied on the (WQES) show that a big part of water resources is polluted by unchecked discharges and urban waste water not uncluttered Fig.5. For Macta basin about 142704 m^3/day is rejected by only the three important agglomerations Table.5. Mascara, Saida and Sidi Bel Abbes, 6567.13 m3/day is the discharges of industrial waste [19], also the dysfunction of water-treatment plants and the connecting of the industrial units in sewer systems or discharge in the environment is conditioned by the preliminary installation of a water-treatment plant, but this regulatory measure is not applied so the water quality is then affected. These rejections settle in dams lead to a reduction of dam's capacities. The registration of degradation of the quality of waters dams, owed essentially to the discharges of cities and industries situated upstream.

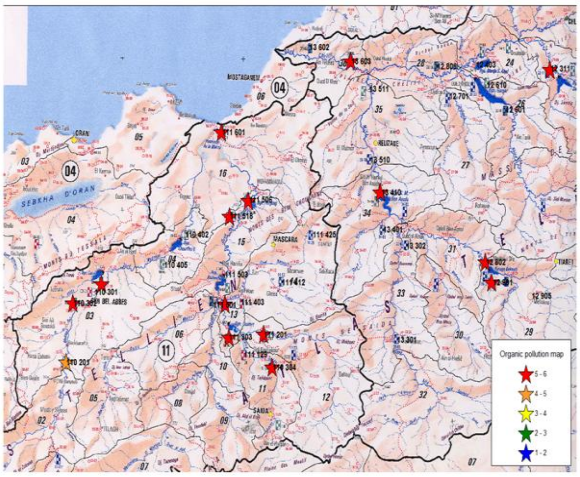

Figure.5 Organic pollution map of Macta and Tafna basin

3.3 Water pollution by heavy metals

Derived from anthropogenic activities, Total Chromium (Cr), Copper (Cu) and Mercury (Hg) are considered to be the most significant heavy metals influencing the water quality in the west of Algeria. Heavy metals Index (txm) distribution represented by the "Fig.6" indicate that all stations have Itxm >3, all the three basins exceed the limit of the Third class "Table.3"; this results confirm that the surface water are contaminated essentially by Chromium and Hg. The World of Health Organization (WHO) recommend as limit values: 50 µg/L for Total Chromium, 2000 µg/L for Copper and 1 µg/L for Mercury. The concentrations of these metals are over the third class thresholds values, so for the Itxm = 1 or 2 and 3 the limit values don't exceed the WHO recommendations; because the WQES use very low and sever limit class concentrations defining toxic heavy metals class. Only the forth and the fifth class present high values of limit class; for that, the WQES is rigorous and sever system.

Heavy metals in water increase the health risk to population around the water sources, this risk is then magnified the accumulation of heavy metals into the human body by the consumption of water and food containing toxic heavy metals. Industry waste water and Sewage irrigation are the main sources of heavy metal pollution [20].

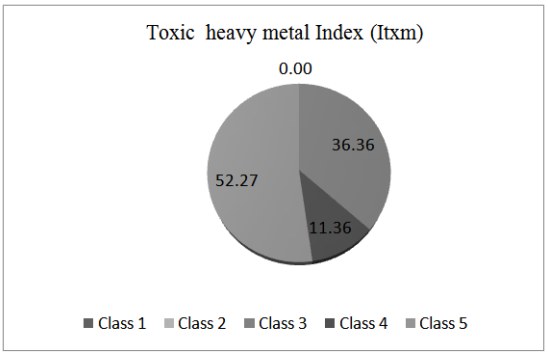

Figure6. Heavy metals Index distribution

3.4 The Global Quality Index (GQI)

According to the methodology of WQES, the Global Quality Index (GQI) presented in table 4 indicate (GQI= 5), water quality is very poor and degraded for all stations measures; unfortunately it is an alarming results for public services; so assessment and treatment become essential to insure the water requirements of the region. Industrial plants equipped with water treatment units discharge the water directly into the River; Water discharged from industry has various chemical parameters (heavy metals organic pollutants) with higher concentration than the wastewater from the city [21, 22].

IV. CONCLUSION

The adoption of the Water Quality Evaluation system (WQES) for the three basins in the North West of Algeria is applied. The WQES gives a very accurate water quality by means of different classes that range from blue to red with quality indexes enabling the monitoring of surface water quality.

The results revealed that more than 60 % of the measures stations have a very bad quality (Iorg= 5) for different type of indexes. The critical shortage of water in the west of Algeria caused by the irregular precipitation and the high consumption of surface water are the principle mineral alteration.

The abundance of organic pollution is related to the human activities, industrial plants, showing organic pollution domination in overall the three basins and particularly the station close to the agglomerations: Tiaret, Mascara, Sidi Bel Abbes, Tlemcen, and Maghnia.

Total Chromium (Cr), Copper (Cu) and Mercury (Hg) are considered to be the most significant heavy metals influencing the water quality in the west of Algeria. The concentrations of these metals in water surface were higher than the WHO recommendation

The thresholds of parameters for African countries must be revised in accordance with the geographic situation of surface water and the shortage water must be taken into account. It might also be more efficient to give more attention to the waste water treatment plant (WWTP), Insufficient treatment (WWTP malfunction), the ineffectiveness of the treatment may be caused by the pollutant concentration load too high to treat, so the waters undergo treatment before being rejected into the waters courses to avoid water quality degradation.

Finally, according to the methodology of WQES, the Global Quality Index (GQI) indicates a very poor and degraded quality for the study area. Unfortunately it is an alarming result for public services, so qualitative assessment and treatment of water becomes essential to insure the water requirements of the region.

The WQES is a necessary tool for decision-makers such as managers, technicians, users and politicians. Therefore, thresholds values of chemical parameters have to be adjusted with Algerian regulations and WHO recommendations. The WQES can be adopted and spreads out of all the rest of Algerian regions and be generalized on North Africa countrie in the near future.

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