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Influence of the Industrial and Urban Waste Water on the Quality of Water (Case of Koudiat Medouar Watershed)

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Abstract: The control of water resources management is credited to the good knowledge of the biological, hydrochemical and hydraulic equilibriums which condition the regional socio-economic future. The effluent of the cities bordering the watershed and the geological formation have obviously important consequences on this equilibria consequences. The physico-chemical quality checkup during year 2005, of the surface water of Oued Reboa and Koudiat Medouar watershed shows that this water is greatly influenced by geology, very graded in heavy metals (iron and lead) and very pronounced by strong contents in nitrates and ammoniums du to urban pollution. Hence 42 samples are taken and the analysis by main components with 18 variables has shown that the water is greatly mineralized and relatively poor in oxygen. This study allowed to examine the dissolution of heavy metals in function of simulated flows and to better master and control the dam water which is intented for drinking and irrigation.

Key words: Pollution, metals, model, watershed, content ,oxygen

INTRODUCTION

During precipétation, water runs down, seeps and fills with soils and parent rocks components which assign a basic identity to water. So it can acquire mineral salt in large quantity, calcium, manganese and so forth.

Other elements, resulting from man action, can be induced like nitrates, organic matter, pesticide products, micro-organisms and so on……The nature and the occupancy of soils play a prominent part. Water, encloses substances and micro-organisms, which by their nature and their concentration, can be indispensable, acceptable undesirable and even toxic or dangerous. The water drawn in the naturel medium is generally not used directly for human consumption. It must undergo certain treatments in order to be consumed without danger for the whole population. From the different information, namely medical and toxicological, a relation between the values of a parameter and the effects on health can be elaborated. Quality limits are defined by applying safety and prevention factors in order that no pernicious effet could be observed on the consumer health. Moreover, this research is carried out all over the world by experts under the care of the World Health Organization (WHO).When these quality limits are exceeded, particular actions of health protection are taken according to the nature and the degree of alteration. Thus 42 samples are analyzed between June 2004 and February 2005 on Oued Reboa, Oued Timgad and Koudiat Medaour dam.

NATURAL CONDITIONS

The Koudiat Medouar water shed is located in the northeast part of the city of Batna. East of Algeria- It lies on an area of 590 km^2, controled by a dam bearing the same name with a capacity of 62 Mm^3. The flowing goes from south to north and is fed by storms or by waste water of bordering cities and villages. The interannual average precipitations are about 370 mm whereas the annual average temperature is close to 15°C. The southern part of the land let cropout limestone formation while amost the whole land is coverd by red clay as represented on Fig. 1.

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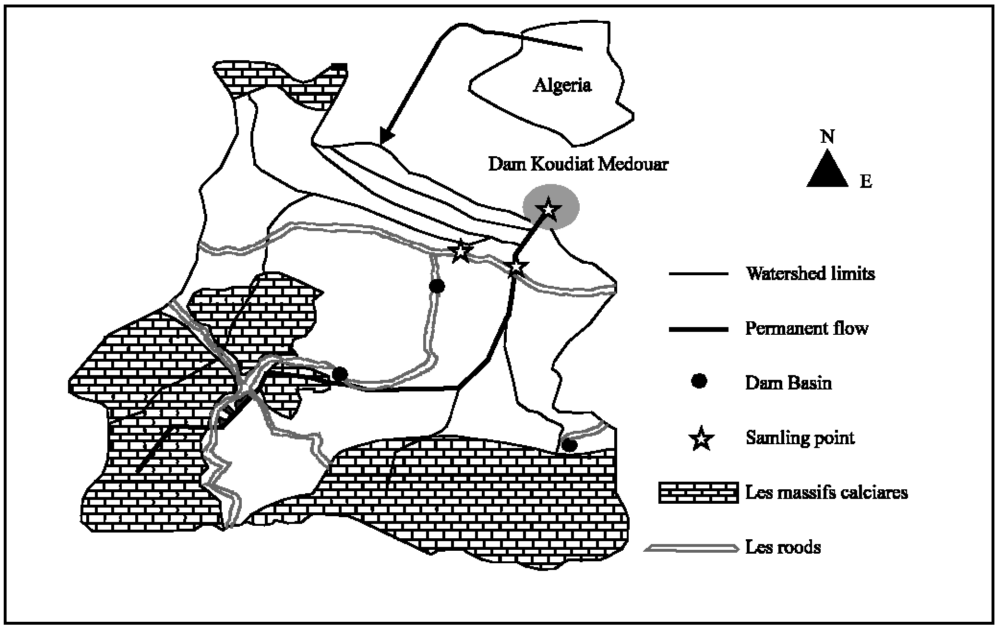

Fig. 1: Map of the hydrographic network and sampling points

RESULTS AND DISCUSSION

Chemical evolution of watershed water: The ten days check up of the water of this watershed was realized at three stations: Oued Reboa, Oued Timgad and in the dam basin.This approach required the examination of two classes of physical parameters (temperature (t), pH end Electrical Conductivity (EC) measured in situ and chemical parameters (Ca^{++},Mg^{++}, Na^{+},K^{+},NH_4^{+}, CL^{-},SO_4^{-}, HCO_3, NO_2, NO_3, DBO_5, DCO, O_2, Pb et Fe) which were titrated in laboraory (Table 1).

The maximal temperature (T_{max} = 25°C) is recorded during the month of June at Oued Timgad and in the dam basin whereas at Oued Reboa the maximal temperature (T_{max} = 23°C) is recorded during the month of July. This slight temperature fall is due to the permanent flow of this latter. The WHO does not recommend any limit values, however a temperature higher than 15°C facilitates the development of micro-organisms and in the same time intensifies the organoleptical parameters such as odours and taste and activate the chemical reactions.

From the results obtained, it is noticed that the pH lies between two values 6.8 and 7.9. According to the potability standards of natural water the pH varies usually between 7.2 and 7.6, moreover it is between these two values where lies the pH of the water reserved for collectivities.

A slight increase is noticed in the pH (pH = 7.9) which can result from the dissolution of limestone grounds existing on the south limit.

The electrical conductivity allows to have an idea about the water salinity. A high conductivity expresses a high salinity. The results obtained allow to say that this parameter in Oued Timgad reaches 1534 µs cm^{-1}, which means that this water has an average mineralization. Whereas in Oued Reboa and in the dam basin the conductivity is about 740 µs cm^{-1}, leading to a low miniralization. The conductivity does reflect a gross mineralization and does not allow to identify the causative chemical element. It is for these reasons that a complete chemical analysis is necessary (Afnor, 1997).

Calc carbonic equilibrium: In order to set up an idea about this phenomenou on we will compare the pH of equilibrium with the pH measured in situ. On this basis that the Oued Reboa and the Oued Timgad water is incrusting whereas that of the dam is aggressive (Table 2).

Hardness of water: The hardress of water depends mainly of the sum of calcium ions Ca^{++} and magnesium Mg^{++}. The trace of other component (constituents) such as the total iron which can contribute to the total hardness. The hardness of water is related to its ability to lather. The hardness is ordinarily expressed in terms of calcium carbonate equilibrium ($CaCo_3$) but it is expressed in french Hydrometric degree (°HF). We observed that the water, in the three stations, is very hard (> 100°F).

Salinity: If the salinity expressed by conductivity is less than 700 µs cm^{-1}, there is no restriction for irrigation

Table 1: Chemical analysis of the water of Koudiat Medouar Watershed

Element	Content in mg L^{-1}		Element	Content in mg L^{-1}		Element	Content in mg L^{-1}	
Ca++	Max.	168.3	HCO3-	Max.	646.60	O2	Max.	1.90
	Moy.	101.2		Moy.	284.30		Moy.	1.00
	Min.	73.7		Min.	97.60		Min.	0.30
Mg++	Max.	154.5	NO3-	Max.	3.60	Fe total	Max.	0.70
	Moy.	91.9		Moy.	1.00		Moy.	0.30
	Min.	61.4		Min.	0.20		Min.	0.10
Na+	Max.	162.8	NO2-	Max.	5.10	Pb	Max.	0.94
	Moy.	87.3		Moy.	0.20		Moy.	0.49
	Min.	35.7		Min.	0.02		Min.	0.08
K+	Max.	9.9	HN4+	Max.	9.30	pH	Max.	7.90
	Moy.	3.9		Moy.	1.10		Moy.	7.50
	Min.	1.0		Min.	0.01		Min.	6.80
Cl-	Max.	184.6	DCO	Max.	80.00	T°C	Max.	25.00
	Moy.	58.2		Moy.	29.60		Moy.	19.60
	Min.	14.2		Min.	0.01		Min.	7.00
SO4--	Max.	186.0	DBO5	Max.	160.00	R.S.	Max.	1900.00
	Moy.	146.0		Moy.	40.00		Moy.	810.00
	Min.	69.0		Min.	0.01		Min.	290.00

Table 2: Water aggressivity

Stations	Average measured pH	Average equilibrium pH	Observation
Oued Reboa	7.55	7.49	Incrusting water
Oued Timgad	7.36	7.29	Incrusting water
Dam	7.52	7.76	Aggressive water

(Lier, 1996). If the conducivity lies between 700 and 3000 μs cm^{-1}, the restriction for irrigation is high (Seltz, 1946).

We notice

- Oued Reboa: 65% of water does not present any restriction for salinity and 35% light to moderate.
- The entire water of Oued Timgad is light to moderate.
- In the dam basin 29% of water does not present any restriction and 71% light to moderated, this is due to the effluent of Oued Timgad (Table 3).

Statistical study: The statistical study of the physico-chemical data in a list of 18 variables and 42 samples, by means of Main Components Analysis (MCA), shows that the majority of the factorial weight is pointed out by axix I, II and III with a total variance of 65%. We note that for 42 samples the critical correllation factor r = 0.56 (r^2 = 0.30). The examination of the relation of the different elements with the different factors (Table 4) shows the exixtence of two sets of variables in good correlation between them.

- The axis I expresses 35% of the variance. It explains the salinity by opposition between the pole Ca^{++}, Mg^{++}, K, Cl, Na, SO_4 HCO_3, NO_2 and the dry resdue and the pole O_2 associated to the pH. This axis represents more the geological origin of the salinity during the dry period, thus in a non influenced regime. We also notice that the nitrates can have a geological origin because they are in good correlation with the remaining elements on one hand and their low content on the other hand (3 mg L^{-1} at most).
- The axis II expresses 20% of the total variance, it is fixed by the urban pollution indicators (DCO, DBO5 and NH_4^+), the temperature where this parameter arises in the dissolution and the lead. The lead can have an origin related to waste water hawing a more or less high temperature.

Table 3: Study of salinity

Restriction for salinity	CE (μS cm^{-1})	Samples percent at different stations: Oued Reboa	Oued Timgad	Barrage
Any	>700	64.28	-	28.57
Light to moderate	700-3000	35.71	100	71.42
High	>3000	-	-	-

Table 4: Study of variables

Physico-chemical parameters	Axis F_1 C*	Axis F_1 r^2	Axis F_2 C*	Axis F_2 r^2	Axis F_3 C*	Axis F_3 r^2
Ca^{++}	0.83	0.69	0.30	0.09	0.25	0.06
NH_4+	0.36	0.13	-0.66	0.44	0.13	0.01
Mg^{++}	0.84	0.71	0.34	0.11	0.21	0.04
Na^+	0.82	0.68	0.31	0.09	0.07	0.00
K^+	0.84	0.71	-0.17	0.03	-0.24	0.05
Cl^-	0.93	0.88	-0.13	0.01	0.03	0.00
SO_4	0.65	0.42	0.24	0.06	-0.08	0.00
HCO_3	0.67	0.46	-48.00	0.23	-0.02	0.00
NO_2	-0.05	0.00	0.09	0.00	0.54	0.20
NO_3	0.54	0.29	0.41	0.17	0.47	0.22
O_2	-0.66	0.44	0.06	0.00	0.49	0.24
Pb	-0.26	0.07	-0.74	0.55	0.44	0.19
Fe	0.00	0.00	-0.18	0.03	-0.57	0.33
DCO	0.22	0.05	-0.53	0.28	0.30	0.09
DBO_5	0.25	0.06	-0.69	0.48	-0.04	0.00
pH	-0.42	0.18	-0.14	0.02	0.19	0.03
T	-0.44	0.19	-0.69	0.48	-0.04	0.00
Rs	0.93	0.88	-0.04	0.00	-0.03	0.00

C*: Variable coordinate in the projection plane

- The axis III expresses 10% of the variance and it is determined only by the total iron having a different origin from the remaining elements.

STUDY OF THE VARIATION OF TOTAL IRON AND LEAD

Possible origins of iron and lead: Iron ranks as fourth element of the earth crust. The surface water can contain some mg L^{-1} of iron having for origin the lixiviation of crossed grounds or industrial pollution. The toxic effects, related to the quantity of ingested alimentary iron, can appear beyond 20 mg kg^{-1} of the body weight. The killing proportion for human being is estimated to 250 mg L^{-1}. Independently from a distasteful flavor which can be perceived beginning from 0.05 mg L^{-1}. For industrial uses, in particular for alimentary industries, it is recommended to not excced 0.2 mg L^{-1}. The analyses, which were realized, showed contents exceeding the allowable maximum contents and they are about 0.53 mg L^{-1} which represents 1.76 times the allowable maximum concentration setup by the europeen community.

The lead is a natural constituent, found in great quantity in the earth crust with content close to 13 mg kg^{-1}. The acid soils are generally less richer in lead than alkaline soils. It can be present in from of carbonate (celuste), phosphate (pyrophosphate), but mostly in from of sulfide (galena). The surface water not contaminated, does not exceed about ten micrograms per liter.

The presence of lead at high content, either soluble or fixed to substances in suspension, should be related to external cause. This metal is in fact so spread and so used in the industry that the possibilities of pollution are extremely numerous and diversitied. The chemistry of lead in water being of a very difficult nature because other parameters are to be considered. The water temperature involves a more important solubility of lead in hot condition than in cold one and interfere also on the pH. The stagnancy time has also its importance. In practice, it was estimated that the maximum quantity of lead likely to be dissolved is generally reached after 12 h of contact. The Europeen community council instructions assess a level guide of 0.05 mg L^{-1} for surface water intended for alimentary water production and an allowable maximum concentration of 0.01 mg L^{-1} for people consumption. According to our analyses, we noticed that the lead contents at the three sampling stations have exceeded the maximum concentration and we recorded a maximum value of 0.94 mg L^{-1}, a value 19 times greater than the prescribed standard of the EEC (Table 4) (Derradji, 2004; ISO, 1991).

Relationship iron-lead: The absence of signifcant correlation between these 2 elements shows their different origin. In fact the lack of mineralization trace of polymetallic deposits in the wateirshed exclude the geological origin of lead. This element could not have as origin other than the waste water which guarantees a continuous water flow in this stream. On the other hand, the presence of red facies in clays which cover almost the entire land explains the presence of iron in sufficient quantity in the surface water of the region. A lixiviation can confirm this hypothesis (Doler, 1995).

Hydrological cycle index: The checking up, through a decade of the evolution of the total iron and lead depending on the physico-chemical parameters of the surface water in the dam and in the principal streams of the region, shows that the evolution of concentrations of these two elements is related to the two following parameters:

- The rain: The concentrations of iron and lead progress in an opposite manner. Thus for iron the lowest concentrations (0.20 to 0.26 mg L^{-1}) are recorded during the uninfluenced period, whereas the highest concentrations are recorded during the rainy period (0.3-0.4 mg L^{-1}). This increase is due, no doubt, to the leaching of this element which is likely to be found in clays with red facies. On the other hand for the lead, the highest concentrations are recorded during the dry period when the flow is related only to waste water, thus concentrated. Whereas during precipitations, the volume of water in the dam and in the streams is more important, which induce the dilution of this element.
- The temperature: The lead concentration progresses in a positive manner with temperature (r = 0.58) which facilitate the dissolution of this elementon the other hand for total iron this relationship is less obvious (r = 0.30) (Ambroise, 1999; Alexandre, 2003).

Evolution of iron and lead: Three periods are marked out in a close relationship with the dam flow.

- The period from June 15th to October 30th when the concentration continues to decrease for the two elements, iron and leade. For this latter, the decrease is brutal and it goes from 0.95 to 0.38 mg L^{-1}.
- The period from October 30th to December 30th when the iron concentration continues but at a weaker rate.
- From December 30th the two elements decrease a the same time Fig. 2.

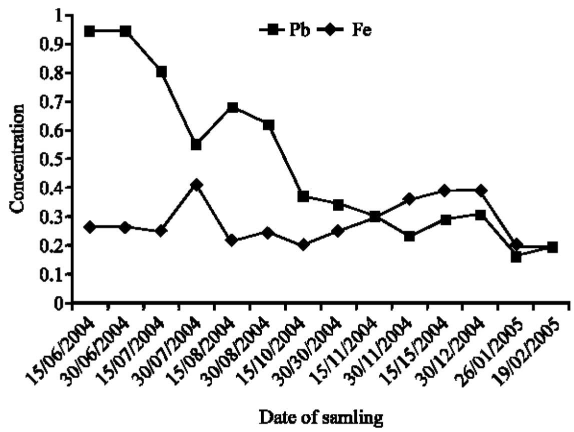

Fig. 2: Evolution of toxic elements in function of time at the dam out flow

DIAGENETIC INDICATORS

The reduction degree can be also expressed for a carbon mole ($\alpha = \varphi[C]$), thus allowin the comparaison of compounds with different carbon content which corresponds to the reduction degree γ according to Edelin (1993).

The number of available electrons is thus a tool of organic matter caraterization, which allows to quantify the Chemical Need for Oxygene (CNO). Multiplying by 4 the CNO we obtain directly the reduction degrees of the present organic matter. According to Edelin (1993) the ideal γ for bacterium will be 4.50:

$\gamma < 4.5$: Organic matter too rich in carbone and not enough in energy giving.
$\gamma > 4.5$: Organic matter too rich in energy and deficient in carbon.

The test of the biochemical demand in oxygen is constantly a subject of different discussions. Improved and precise in conditions of pH, temperatures, well determinated salinity, it constitutes however, a valuable mean of study of natural phenomena which destroy the organic matter.

The ratio DCO/DO_5 allows to appreciale the degradability of the organic matter (Pelet, 1981).

It is close to 1.5 for drinking water, to 2 for the urban waste water and varies between 3 and 5 for the effluents sprung from filtering stations and industrial areas; the increase of the ratio indicates an increase of the non biodamageable organic matters (Table 5).

Table 5: Ratio DCO/DBO_5

Date of sampling	DCO (mg O_2 L^{-1})	DBO_5 (mg O_2 L^{-1})	$\frac{DCO}{DBO_5}$
15/06/2004	80	40	2.00
30/06/2004	70	25	2.80
15/07/2004	76	20	3.80
30/07/2004	50	140	0.35
15/08/2004	16	50	0.32
30/08/2004	33	40	0.82
15/10/2004	25	20	1.25
30/10/2004	19	19	1.00
15/11/2004	15	20	0.75
30/11/2004	20	10	2.00
15/12/2004	18	15	1.20
30/12/2004	15	10	1.50
26/01/2005	16	5	3.20
19/02/2005	15	5	3.00

CONCLUSION

We have noticed that the calculated values of the ratio DCO/DBO_5 are all below 5 which means that the water of Oued Reboa does not contain nonbiodamageable organic matter.

However, we have recorded a maximum value of 3.8 for the ratio during the month of July, which confirms that the water is polluted by the urban effluents. It seems that the surface water in the dam is more affected by the supply of a mineral pollution than a urban one. The geology has also a negative impact on the quality of this water loaded more and more by iron.

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