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Characterization of Surface Water Quality Crossing through Saids's City (Case: Said's Wadi – Alegria NW)

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Abstract

Saida's wadi is one of the main permanent watercourse of superficial network of the west region in Algeria, presently affected by pollution generated by human activities (urban, industrial and agricultural waste) with the aim of identifying pollution status of this watercourse of these last years, our work was focused on determination of chemical-physics parameters and bacteriological water in the stretch of Saida's City.

The results obtained describe in a clear existence of chemical and organic pollution at level of the three stations studied due to increase of calcium, magnesium, chloride, nitrate, nitrite, orthophosphate, BOD5 and dissolved oxygen. Except for nitrate in the centre and downstream of the city where their average contents decrease (S1=1,133mg/L and S2=2,06mg/L). This is probably due to phenomena of nitrate transformation into nitrite, consumption of nitrate by microorganisms. Indice's evaluation of organic pollution confirms that there is an important organic pollution upstream and increases during the passage of rainwater in urban environment (stronger IPO). On the bacteriological level, results obtained show presence of a high load of bacteria inducing faecal contamination (totals coliforms, faecal coliforms and faecal streptococcus. The report between FC/FS shows that there is predominance of human origin contamination than of animal. Totals mesophile germs are also important notably at 22°c. As for pathogenic germs, genders of salmonella have not been detected.

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Analysis results of water on the two levels (chemical-physics and bacteriological) allow us deducing that quality of these waters is average to poor during their passage in the city and thus, cannot be used for marked gardening irrigation in the region. It is therefore required to intervene urgently to rehabilitate this site.

Keys words: Wadi Saida, pollution, chemical-physics, bacteriology.

1. Introduction

Resources water, whatever is in surface or ground waters, have a direct impact on socio-economic development of a region [4]. Several countries are presently facing by water shortage due to demand that is growing exponentially in domestic water, agricultural and industrial. Additionally, climatic changes and generally episodic droughts [9]. This issue is not restricted to quantity of water resources, but it is also based on quality of these resources that we need more than ever to manage with efficiency [7]. On 13.600 million km^3 of water covering our Planet Earth, only 0.014% is fresh water used by human in the form of fresh water.

If this quantity is sufficient to meet future humanity's needs, altered quality of water which makes compatible part with uses getting a smaller and smaller [10].As a matter of fact, water quality is altered by various pollutant discharges (industrial, domestic, agricultural), generally, generated, by anthropogenic activities. Those last ones are at the origin of most of these streams pollution problems [7]. Wadi Saida, considered as one of the main permanent stream of surface network which provides about 100 hm^3/year with wadi Hammam, wadi El Mimoun and wadi Taria [13], today becomes as dump of all sorts of waste (liquid and solid), and this in spite of great efforts provided by local authorities benefiting the environment, notably, in term of recovery and treatment of waste water. Effects of these different discharges on environment are not being felt only at level of zone of wadi Saida's valley which comprises agricultural lands oriented essentially towards market gardening and fruiticulture and the important existing water table, but also at level of regions located downstream, especially if one considers that waters of this wadi are collected by Ouizert's dam of Mascara's Wilaya [11].The study choice of this stream depends on both of its sustainability all over the year and to its role in economic development, notably in agriculture, of urban centres nearby. The purpose of this present work is to identify pollution status of this watercourse of those last years through a spatio-temporal follow-up of bacteriological chemical-physics quality of its waters in the stretch of Saida city for the purpose to protect population health and also to preserve environment.

2. Presentation of study area and choice of stations

2.1. Geographic location of the study area

The City of Saida, main-town of Saida, located at about 180 km to South of Oran wilaya and of 70 km of Mascara Wilaya. In the North it is limited by Rebahia municipality, in the South by municipality of Ain El Hadjar, In the East by municipality of Hassasna and in the West by municipality of DouiThabet. Its area (Fig .1) spreads on 73.80 km^2 for a population estimated in 2009 at around 130.805 inhabitants. In addition of its geographic location, the region possesses significant advantages in resource matter (deposits, water resources, agricultural, ecological, industrial, touristic and historic [14].

Wadi Saida, which represents extension of wadi Tebouda, is one of the main streams in west region of Hauts Plateaux (Algeria) it has its source in the South of Ain El Hadjar's municipality at around of 03 km where it is supplied in the region by the great source of Tebouda (flow = 30 l/s). It follows an approximate direction NW-SE on stretch of 04 km then on a distance of 08 km direction NE-SW until South limit of Saida City and NNE-SSW to NS until the exit of Hammam Rabbi's urban [11]. Several karst springs (Vieux Saida, Ain El Baida .., etc.) participate to the flow of this watercourse [15]. Its watershed covering an area of 543.7km^2 for a perimeter of 104km, and is a part of the great watershed of la Macta which is spreading in North-West of Algeria [9].The climate of Saida Wilaya is generally semi-arid with temporary flow, characterized by a cold and rainy winter, and a dry and hot summer. Average annual rainfalls are marked by a net irregularity in time and space with an equal value of 327 mm between 1979 and 2007 [13].

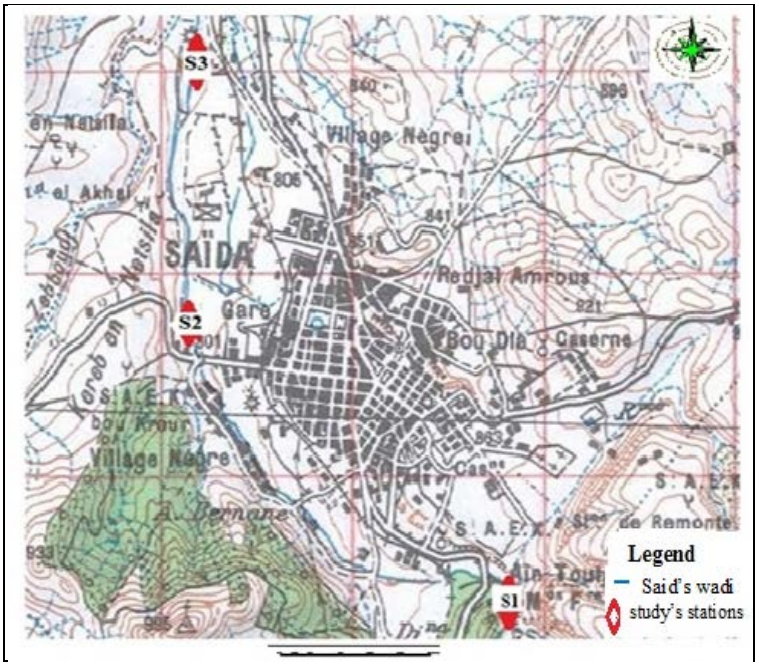

Figure 1: Location of Saida city and study's stations

2.2. Description of study's stations

Water samples have been collected in the stretch of Saida City at 3 significant points of sampling according to their representativeness: pollution sources, and accessibility. These sampling points are from upstream to downstream of Saida City (Fig.1).

- Station n°01: It is located at the south entrance of Saida city, in a recreational forest of Touta. It receives water from the great source of the region (source of Tebouda with a flow of 30 l/s). Added to this treated waters at level of station of Ain El Hadjar and so those of karst sources existing in its way.

- Station n°02: is located in the center of the city, in an urban zone, particularly dense and receiving domestic wastewater and solid discharges (households waste, worksite waste), etc ;

- Station n°03: is located at the exit out of Saida City, near the municipality of Rebahia containing on its left bank, industrial installations and receiving domestic wastewater particularly from inhabitants nearby of Saida wadi.

3. Materials and Methods

3.1. chemical-physics analysis

Samples have been collected during periods of June 2011, July 2012 and April 2013 from upstream to downstream of Saida ciy. At each sampling, temperature (°C) and pH are in-situ measured. Water samples have been kept at 04 °C in a cooler during transport to laboratory of the centre of measurement in chemistry of Sidi bel Abbès' university where they are analyzed within 24 hours. The analysis methods adopted for determination of calcium, (Ca^{++}) magnesium (Mg^{+2}), Chlorides (Cl^{-}), nitrate ($NO3^{2-}$), nitrite (NO^{2-}), sulphate ($SO4^{2-}$), ortho-phosphate (PO_4^{3-}) and dissolved oxygen (O_2), dry residue (DR), of biological demand in oxygen during five days (BOD5) are those quoted by Rodier (2009)[20].

3.2. Bacteriological analyses

Bacteriological analyses have been focused on pollution indicators which gather faecal contamination bacteria such as: total coliforms, (TC), faecal coliforms (FC), streptococci faecal (SF), Total Mesophile Aerobic Germ (TMAG) at 22°C and 37°C, and some pathogen germs (the salmonella). Without means preventing us to make analyses according to the same frequency of those of chemical-physics, samples have been collected during periods of March 2011, September 2012 and May 2013. The counting of TMAG is made by seeding in surface on agar medium (T.G.E.A). The reading is done after 48 hours of incubation at 37°C or after 72 hours of incubation at 22°C. Totals coliforms and faecal have been done by seeding in liquid medium (colimetry) the same method for streptococci. Serial dilutions (until 10^{-6}) have been done for all samples to facilitate counting. As for pathogen germs, enrichment is made in boiling tube with sodium selenite. Incubation is carried out at 37°C. Used methods in evaluation of bacteriologic quality are those advocated by Rodier (2009) [20].

4. Results and Discussion

4.1. chemical-physics quality

Chemical-physics parameters supply indications on water quality, but they are subject to variations by anthropogenic activities which modify water characteristics [16]**.** Results of chemical-physics measured on the field are presented in table 1; in the whole, these parameters present a relative stability during the three periods of sampling. Temperatures recorded at level the three stations (Table 1) vary en general between 23°C and 24°C, except for the last sampling (2013) where temperatures record a regression, particularly at level $\mathbf{S_1}$ (14°C) which is important, this is due to the climate impact. As for Ph, values observed at level of the three stations (Table 1) show that waters of wadi Saida are in the neutrality range (6,5 and 8,5). Comparison of these results with those carried out in 2007 by Hachemoui (2007) show a slight decrease (7,5 à 9). Electric conductance informs on degree of mineralization of a water, a high conductance translates either by an normal pH or by most

often a high salinity [6], results observed at level of the three stations (Table 1) are variable and their average values oscillate between 1118 and 1638 µS/ cm, they follow an increasing gradient from upstream to downstream of Saida City. These important values in CE can be justified by concentration of some mineral elements as chloride with average value varying between 175 mg/L and 246 mg/L , and between 108 mg/L and 303 mg/L for sulphate (SO_4^{-2}) (Table 1) are both elements the most dominant of water soluble salts in Wadi Saida, and that is due to wastewater discharges for chloride and to geological nature of the ground crossed by the wadi for the second element. To these concentrations in Cl^- et SO_4^{-2} which generally follow a progressive way from upstream to downstream of the city, it is added contents in calcium (Ca^{++}) and magnesium (Mg^{+2}) (Table1) where average values vary respectively between 108mg/L to 150mg/L and 77mg//L to 99mg/L. increase of Ca^{++},particularly at level S2, may be obviously explained by the ground nature crossed (presence of limestone and dolomite) [18].

This strong mineralization is also reflected by high contents of dry residue (Table 1) with average values comprised between 990mg/L upstream and 1395mg/L downstream of Saida City. This importance is due to domestic agricultural and industrial discharges. As for nitrate (NO_3) which generally come from soil activity [15], their concentrations in natural waters are comprised between 1 and 10 mg/L [3]. Results obtained (Table 1) show that contents in NO_3 follow a decreasing gradient from upstream to downstream with a low value in S2. It is of average of 38,50 mg /L at level S1, that is may be justified by human action, particularly agricultural which dominates nearby wadi and presence of recreational forest (Touta), and of 1,133 mg/L and 2 ,06 mg/L in average at level of S2 and S1 respectively. This important decrease in NO_3^- at level of these last stations can be explained by transformation of nitrate into nitrite, to the action of micro-organisms (self-purification is active) and to soil occupation. As for nitrite (NO_2^-), results obtained (Table 1) show that those ones follow an increasing gradient from upstream to downstream of Saida City. Their average values oscillate between 0,5 mg/L at level S1 to 0,77 mg/L and 1,12mg/L at level S2, S3 respectively. This evolution in NO_2^- is due to existence of discharges, particularly of organic nature, in the trajectory path of wadi, and also to waste water discharge.

About orthophosphates (PO_4^{3-}) which essentially come from domestic activities (organic rejects of organic pollutants) but also of industries and agricultural via soil erosion. Upper contents to 0,1mg/L constitute an indice of pollution [12]. The results recorded (Table 1) at level of the three stations (S1 = 0,5mg/L, S2=1,13 mg/L, S3=2,06 mg/L) show that ions PO_4^{3-} evolve with a progressive manner from upstream to downstream. This increase is due presumably to sources diversity of orthophosphates ions (agricultural, domestic and industrial).

Quantities of dissolved oxygen (dissolved O_2) evaluated in samples harvested during chronology previously mentioned show that average values of those ones (Table 1) increase of S1 (4,41mg/L) to S2 (12,7mg/L) passing by S2 (5,55mg/L). This deficit in dissolved oxygen may be justified by different spillages loaded with organic elements along the wadi Saida such as: waste waters, household discharges, vegetal flows, animal manure, etc…In regard of biologic oxygen demand (BOD5), results obtained (Table 1) show that the last ones show important spatio-temporal variations with average values varying between 7,33mg/L at level S1 and 290 mg/L, 211mg/L at the station S2 and S3 respectively. This increase in BOD5, especially in S1 and S2, would be due to the effect of different rejects (urban, agricultural, and industrial) discharged in the flow direction of Saida wadi With reference to Algerian Standards of Surface Waters [1], results of chemical-physics obtained show that

waters of Saida wadi in the stretch of Saida City are classified in category of waters with average to poor quality for certain elements (NO_2^-, PO_4^{3-}, BOD5, dissolved O_2).

Table 1: Physical and chemical results of water samples analyzed Saida'sWadi.

Parameters	units	Station 01	Station 02	Station 03
average values of undesirable elements				
pH	-	7,64	7,81	7,74
Temperatures	C°	20,73	21,83	21,26
Conductances	µs /cm	1118	1546	1632
average values of mineral quality				
Calcium (Ca^{++})	mg /l	108,01	146,87	150 ,30
Magnesium (Mg^{+2})	mg /l	90,74	99,63	77,15
Chlorides (Cl^-)	mg /l	175,99	271,66	246,99
Sulphate (SO_4^-)	mg /l	181,47	243,75	303,07
dry residue (DR)	mg /l	990	1062	1395
average values of nitrogenous				
Nitrates (NO_3^-)	mg /l	38,5	1,133	2,06
Nitrites (NO_2^-)	mg /l	0,5421	0,77	1,1262
average values of orthophosphates				
orthophosphates (PO_4^{3-})	mg /l	0,573	1,13	2,06
average values of organic quality				
dissolved oxygen	mg /l	38,5	1,133	2,06
biologic oxygen demand	mg /l	0,5421	0,77	1,1262

4.1.1. Evaluation of Organic Pollution Indice (OPI)

There are several indices of organic pollution determination which have been established by several authors. We are interested by work of Leclerq and Maquet (1987) with the principle to spread values of pollutant elements (DOB5, Nitrite, Phosphate, and Ammonium) in 05 classes, to determine from its own measurement, the number of corresponding class for each parameter to make the average [5]. In this work, parameters taken into consideration are those of de (DOB5, PO_4^{3-}, NO_2^-) ,Table 2 shows organic pollution of wadi Saida's waters increasing from upstream and accentuated during its passage into urban environment until downstream.

Table 2: Index of organic pollution (IPO) of the plants studied at the Saida's Wadi.

Studied stations	OPI for each station studied	Pollution class for each station
Station 01	02	strong organic pollution
Station 02	01	very strong organic pollution
Station 03	01	very strong organic pollution
OPI= Average numbers of the classes of 03 parameters: OPI= 5,0 – 4,6 : zero organic pollution, OPI= 4,5 – 4,0 : low organic pollution, OPI = 3,9 – 3,0 : moderate organic pollution, OPI = 2,9 – 2,0 : strong organic pollution, OPI = 1,9 – 1,0 : very strong organic pollution.		

4.2. Bacteriological quality

Bacteriological analyses allow showing bacterial species introduced in waters, and which can cause environmental disruptions and obviously hazards to population's health [2]. Research results of the totals aerobic mesophile germs (at 22°C and 37°C) show that those ones are developing by following an increasing gradient from upstream through downstream of Saida City. At 37°c (Table 3) the average minimal value is recorded at level S1 with concentration of $1,98\times10^2$ UFC/100 ml while the most important values are recorded at level S2($4,67\times10^5$ UFC/100ml) and S2 (7 ,47UFC/100ml). At 22°C (Table 3), concentration of totals mesophile germs varies between 3, 98×10^4 UFC/100ml in S1 to $2,08\times10^5$ UFC/100ml and $1,11\times10^6$ UFC/100ml at level S2 and S3 respectively.

These results observed reveal that totals of microorganisms enumerated at 22°C are higher than those counted at 37°C that is probably due to the fact that autochthon bacteria are the dominant compounds of the total population even in the polluted streams [2].Generally, at 37°C the totals microorganisms are bacteria of intestinal origin (human or animal) [8]. For inducer of faecal contamination bacteria, results observed (Table 3) show a spatio-temporal evolution from upstream towards downstream of the town with an accentuation at level S1 and S2. This is due to domestic discharges, leaching of agricultural soils loaded with organic elements of animal origin, and to direct discharges of livestock manure. Values of totals coliforms (TC) (Table 3) oscillate between $1,62\times10^3$ /100ml in average at level S1 à $2,91\times10^5$ /100 ml and $5,64\times10^5$ /100ml in average at level S2et S3 respectively. As to faecal coliforms, their evolution is linked to those of totals coliforms, average values recorded (Table 3) are important, particularly in S1 (2×10^3 /100ml) and S2 ($6,46\times10^4$ /100ml), and that confirms faecal contamination of Saida wadi's waters. Research of faecal streptococci in the three stations studied show and affirm a faecal pollution of human and animal origin, results (Table 3) the most significant are those observed at level S2 ($1,36\times 10^5$ /100ml in average) and ($5,33\times10^5$ /100ml in average). As for pathogen species, salmonella gender, analyses performed on water samples collected during the three periods previously mentioned show absence of this gender of microorganisms in spite of the high load of indictor bacteria of faecal contamination, the probable existence of these microorganisms at viable state non-cultivable would call into question, the techniques of conventional culture used [7]. Several studies suggested that pathogen bacteria could

maintain their pathogenecity in viable state non cultivable [19, 17].

Table 3: Bacteriological results of water samples analyzed Saida'sWadi.

Parameters	units	mean values of three sampling periods		
		Station 01	Station 02	Station03
Total Mesophile Aerobic Germ à 22°C	UFC/100ml	$3,98\times10^4$	$2,08\times10^5$	$1,11\times10^6$
Total Mesophile Aerobic Germ à 37°C	UFC/100ml	$1,98\times10^2$	$4,67\times10^5$	$7,47\times10^5$
total coliforms à 37°C	Germ/100ml	$1,62\times10^3$	$2,91\times10^5$	$5,64\times10^5$
faecal coliforms à 37°C	Germ/100ml	$1,86\times10^2$	2×10^3	$6,46\times10^4$
streptococci faecal à 37°C	Germ /100ml	$3,20\times10^2$	$1,36\times10^5$	$5,33\times10^5$
salmonella	/	00	00	00

4.2.1. Source of faecal contamination

Origin of faecal pollution is made to quantitative report of faecal coliforms on faecal streptococci (FC/FS) when this report is upper to 4, pollution is essentially human (waste-waters discharge). When it is lower to 0, 7, animal origin, notably livestock particularly sheep, seems playing a predominant role in water contamination [10]. The report between average values of faecal coliforms and faecal streptococci of water analyzed samples of wadi Saida (Table 4) shows that indicator bacteria of faecal contamination are in major part of human origin.

Table 4: Origin of fecal contamination of Saida's Wadi.

Stations	Report CF /SF	Origin
Period of march 2011		
Station 01	0,30	Animal
Station 02	60	Human
Station 03	209,5	Human
Period of september 2012		
Station 01	7	Human
Station 02	00	-
Station 03	2,72	Mixed human dominance
Period of may 2013		
Station 01	00	-
Station 02	00	-
Station 03	0,09	Human
CF/SF<0,7 : Mainly or entirely of animal origin, 0, 7< CF/SF < 1 :Mixed animal-dominance, 1<CF/SF <2 :Origin uncertain, 2<CF/SF <4 : Mixed human dominance, CF/SF > 4 : fully human source (Borrego et Romero ,1982 in Hamid Bou Saad and al. ,2007)		

5. Conclusion

At the end of this work, we came to the conviction that status of Saida wadi's waters are deteriorating from upstream of Saida city and accentuated during their passage in urban environment due to solid and liquid discharges spilled without control, or prior treatment. The spatio-temporal monitoring of the main chemical-physics results shows with a clear manner existence of chemical and organic pollution at level of the stations studied due to the increase of chlorides, nitrates, nitrites orthophosphates, biological demand in oxygen and dissolved oxygen. Exception done for nitrates in the centre and downstream of the town where there average contents were decreasing (S1=1,133mg/L and S2= 2,06mg/L). This is presumably due to transformation phenomena of nitrates into nitrites, consumption of nitrites by microorganisms. Counting of indictor bacteria of faecal contamination (TC, FC and FS) and spatio-temporal distribution of these microorganisms reflected an important faecal pollution where human origin is in large part, the totals Mesophilic organisms are also important particularly at 22°C than those of 37°C. Research of certain pathogenic germs, of salmonella gender, produced negative results. Results of water analysis on both plans (chemical-physics and bacteriological) allow concluding that quality of these waters is *average* to *poor* during passage in the town and cannot be used in the region for irrigation of market gardening. Facing this worrying situation, it is necessary to take into consideration this site in order to protect population health and also to preserve environment.

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