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Study of physicochemical and Microbiological quality of Oued Bouskoura: Peri-Urbain of Casablanca, Morocco

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Abstract

Monitoring of physicochemical and bacteriological parameters was studied at six sampling sites located along the Oued Bouskoura from its source to downstream. The study of various water pollution parameters during the period 2011-2012 showed the vulnerability of the water of the river against the pollution from waste water. Results showed that physicochemical properties of the water were closely related with the distribution of coliforms. Principal component analysis (PCA) shows a strong correlation between the parameters of organic pollution (Pt, PO_4, NH_4, NO_2, COD and BOD 5) and fecal contamination (CT, CF, SF). Thus, it has highlighted on the one hand, the degradation of downstream water quality of the river with a strong organic pollution accompanied by fecal contamination caused by discharges of the industrial zone Lissassfa and Nassim agglomerations. On the other hand, the natural mineralization of the Oued Bouskoura waters was confirmed by high levels (EC, Sal, Cl, SO_4). The monitoring of the parameters of fecal contamination, total coliforms (TC), fecal coliforms (FC), fecal streptococci (FS) shows that the bacterial load of these germs largely exceeds water intended for irrigation guidelines of the World Health Organization's (WHO).

Keywords: Oued Bouskoura, physicochemical, bacteriological, PCA.

Introduction

With the rapid development in agriculture, urbanization, and industrialization activities, the river water contamination with hazardous waste and wastewater is becoming a common phenomenon[1]. The area of big Casablanca (economic capital of Morocco) knows a growing population and continued development of the industrial zone which influences the only superficial network of this city, Oued Bouskoura water resources of the rivers are widely used for various activities: farmland irrigation, car washing, construction of buildings, livestock watering, etc. Draining a part of the pollution load generated by the surrounding towns can be an important source of contamination of the hydrosystem water. Similarly, livestock remains a traditional activity, closely related to aquatic environments, especially rivers, and in turn constitutes a significant source of pollution[2]. However, this river receives discharges downstream of the industrial area of Lissassfa and Nassim agglomeration, which can cause deterioration of water quality, hence the need to reveal this pressure through a hydrobiological study. The present study aims to determine the physicochemical and bacteriological water quality of Oued Bouskoura.

Material and Methods

14 monthly samples of wastewater have been taken at the level of the Oued Bouskoura during a period from February 2011 to March 2012. The state of six simpling stations the Oued Bouskoura (figure 1) is apprehended from measurements of 16 physicochemical and biological variables. The methods used to determine these variables are those recommended by AFNOR[3]. In situ measurements of pH, electrical conductivity, dissolved oxygen and turbidity were conducted respectively by a pH meter WTW conductivity meter WTW, oximeter WTW, and a turbidimeter EUTCH TN-100. Chemical analyzes are: chlorides (Cl), sulfate (SO4), nitrate (NO3), ammonium (NH4), ortho-phosphate (PO4), total phosphorus (Pt), BOD5 and COD. Enumeration of indicator bacteria of fecal contamination has focused on total coliforms (CT) and fecal coliforms (FC), as well as fecal streptococci (FS).

Results and Discussion

Physico-chemical water quality: The evolutionary study of the average contents of the principal parameters and indicators of pollution showed that:

PH, Conductivity and Salinity: The spatial evolution of the results obtained show that the pH of the river is alkaline ranging from 7,84 (B1) and 8,33 (B3). The highest conductivity is observed at the source of the stream B1 (4,78 mS /cm), reflecting the strong mineralization of the groundwater. This value varies between 2,80mS/cm by B2 and 3,98 mS/cm by B4. Salinity follows the same pattern of conductivity; values oscillate between 1,95g/l and 0,85g/l (figure 2a).

Turbidity: The water turbidity studied varies between 4,13 NTU in B1 and 11,91 NTU in B5,. The decrease of the values at

the B4 (4,16NTU) and B5 (7,84NTU) (figure 2b), with a 35% deduction rate, shows the capacity of the watercourse to be auto-cleaned.

Nitrate, nitrite and ammonium: Nitrate, nitrite, and ammonium concentrations were significant, a maximum of 6,14, 2,45 and 4 mg / l was observed in B3 and B6, respectively. Nitrites follow an increasing gradient of the upstream (0,28 mg / l B1) to downstream (2,63 mg / l B6). The decrease in nitrate level B2 and B5 is explained by the presence of industrial releases in Ouled Saleh and Lissassfa. This is confirmed by the increase in ammonium levels at these stations 0,73 mg / l (B2) and 4 mg / l (B5) (figure 2c). These levels are comparable to results reported by Hashemi Rachedi and Amrachi in Oued Meboujda and above to those of Abouelouafa *et al.* in Oued Bounaim[4-5].

Orthophosphate and total phosphorus: The spatial evolution of orthophosphate follows that of total phosphorus, upstream of the river presents with low values which do not exceed 0,21 mg / l (B3) PO4 and 0,57 mg / l (B2) Pt, While downstream where industrial discharges of Lissassfa and agglomerations spilled values increase to 0,97 (PO4) and 1,36 mg/l (Pt) in B6 (Figure 2d). In addition, the decrease in these levels B4 is explained by the phenomenon of self-purification of water during the route crossed from B2 to B3. These results are lower than those recorded in Oued Hassar and higher than those recorded in Oued Fez, Oued Himer (in Morocco) and Vaigai River (in India)[6-8].

Sulfates and chlorides: Sulfates and chlorides follow the same spatial variation, with a maximum in B1 (91,55 and 662,4mg/l, respectively), the enrichment of these waters is probably related to the mineralogical composition of the groundwater. However, the recorded contents exhibit stability after B2, reaching downstream 77,80mg/l sulfates and chlorides to 365,2mg/l (figure 2e).

COD and BOD5: The spatial evolution of COD shows an increasing gradient from upstream B1 (21,38mg/l) downstream B6 (83,78 mg/l) due to the enrichment of the water of the river by the load generated by organic waste. The evolution of BOD5 shows two areas, the first B1 to B3 where a gradient decreasing is recorded with a minimum value of 1mg/l due to decomposition of organic waste under the effect of self-purification, while the second shows an increasing gradient of B3 to B5 (17,45 mg/l) (Figure 2f) where there is dumping of industrial waste in Lissassfa agglomerations Nassim[9]. However, these values are significantly lower than those measured in the Oued Moulouya, Oued Bechar and Kanhan River[10-12].

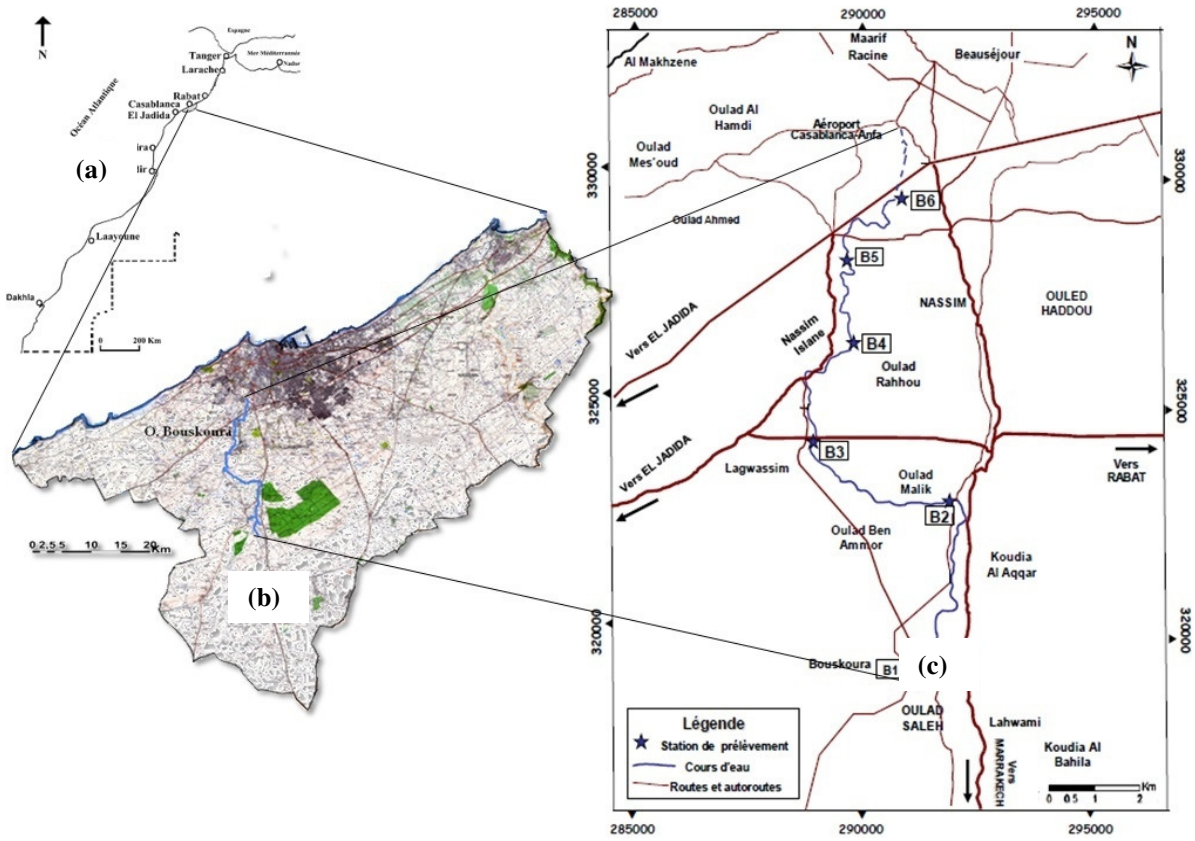

Figure-1
Geographical location of sampling stations (a) Map of MOROCCO, (b) The area of big Casablanca, (c) Oued Bouskoura

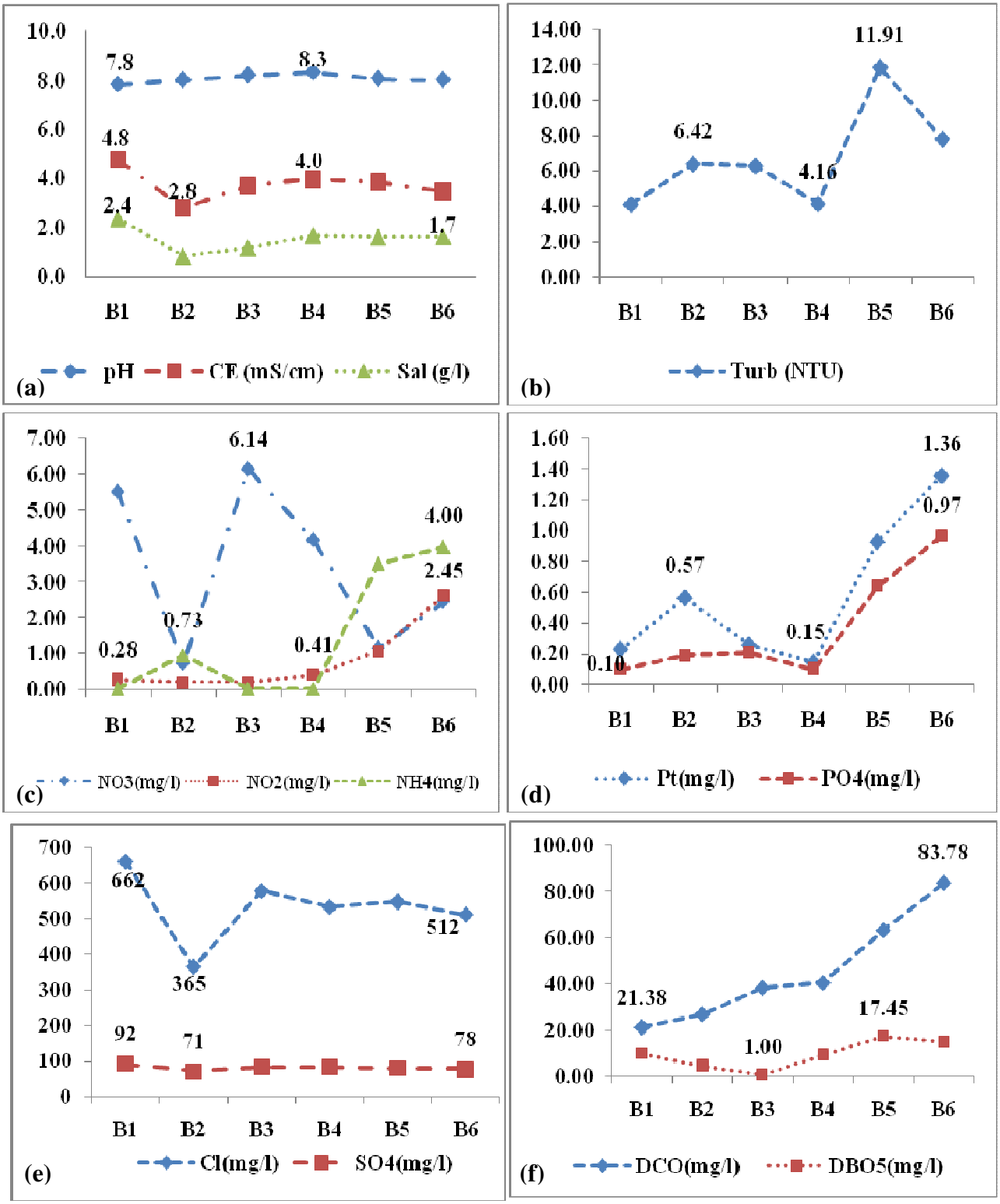

Figure-2

Spatial Evolution of physicochemical parameters (a): pH, Electrical Conductivity (EC), Salinity (Sal). (b): Turbidity. (c): Nitrate (NO3), Nitrite (NO2) and Ammonium (NH4). (d) : Total phosphorus (Pt), Orthophosphate (PO4). (e): Chlorides (Cl), Sulfates (SO4), (f): Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD5)

Bacteriological characterization: The microbiological analysis of water allows assessing the risk from pathogenic microorganisms which may be found in waters used by humans, and thereby cause disease, and can also monitor the effectiveness disinfection treatments[11].

The results show the same spatial evolution of TC, FC and FS respectively with a maximum of 4,91, 4,17, 4,36 Log10CFU/100ml B5, reflecting the deterioration of the water quality of the river Bouskoura by discharges. However, there is a reduction of the bacterial load in B6, which reveals the self-purifying power of rivers. Upstream has a certain stability of the germ concentration is between 3,89 (B1) and 3,60 (B4) in TC, 3,82 (B1) and 3,09 (B3) in FC, 3,62 (B1) and 2,57 (B2) in FS Log10UFC/100ml unit (figure 3).

The origin of fecal contamination, used by Borrego and Romero according to fecal coliforms to fecal streptococci report (table 1), shows that the origin of this contamination is mixed between animal predominance B1 , B4, B5 and B6 to uncertain B2 and B3[13]. The Low bacterial load in the river masked the origin of fecal contamination at B5 where industrial wastes are discharged. Bacterial loads recorded along the Oued Bouskoura exceed that recommended by WHO for irrigation water and which of the order of 10^3/100 ml. However, the results obtained remain far from those recorded at Oued Hassar[6]. But comparable to El Ouali-Alami *et al.* in Oued Himer, Larif *et al.* in Oued Boufekrane[7-14].

Although the origin of bacterial contamination in surface waters is exclusively of human or animal origin, the explanation of the variation in bacterial load is related to the physicochemical parameters that contribute to bacterial activity as the temperature and pH[15].

Statistical Analysis : The principal component analysis (PCA) of all the data obtained on the waters of the river collected in fourteen sampling campaigns in the six sites shows that 84,18 % of the variability of data is extracted by the factorial plane F1 X F2, where the first axis explains 49,72 % of the variance (figure 4), Where the variable structuring positively F1 is NO3.While those structuring negatively F1 are organic (Pt, PO4 , BOD5 , COD, NH4 and NO2) and bacteriological (CT , CF, SF) pollution parameters. F1 axis reflects the degree of organic pollution and bacteriological contamination of the waters of rivers, and it determines the abundance of nitrates (table 2). While the second axis, which represents 34,46 % of the variance, is marked mainly by mineralization parameters (Sal , Cl, EC and sulfate) and turbidity. The axis F2 could be likened to a gradient of mineralization and leaching of soil.

Analysis of physicochemical and bacteriological water Oued Bouskoura principal component ACP revealed the existence of three groups (figure 5): i. A first group in the positive part of the axis F1 (B3 and B4) characterized by high levels of nitrates. ii. A second group in the negative part (B5 and B6) characterized by polluted water and bacteriological contamination due to industrial discharges. iii. A third group where the F2 axis ranks the upstream stations B1 and B2 characterized by turbid and highly mineralized waters located upstream of Oued Bouskoura.

The study of correlation between the variables (table 3) showed positive and highly significant correlations between Pt, PO4, BOD5, COD, NH4, NO2 and CT, CF, SF. However, highly significant positive correlations (P> 0,05) that were observed between the measured variables in this bacteriological study (CT, CF and SF) show that monitoring of one of them is sufficient to characterize bacteriological pollution. The significant variables interconnection (Cl, EC, Sal, SO4, Turb, NO3) defined mineralization is influenced by water leaching soil enriched nitrate ion in particular which can be associated with the use of nitrogen fertilizers. In addition, a negative correlation was observed between pH and indicator bacteria of fecal contamination. These results confirm the work of Mayo and Kalibbala and Ndiaye *et al.*, which showed that the increase in pH affects the abundance of fecal coliforms where basic pH leads to a net decrease in the survival of fecal coliforms[16-17].

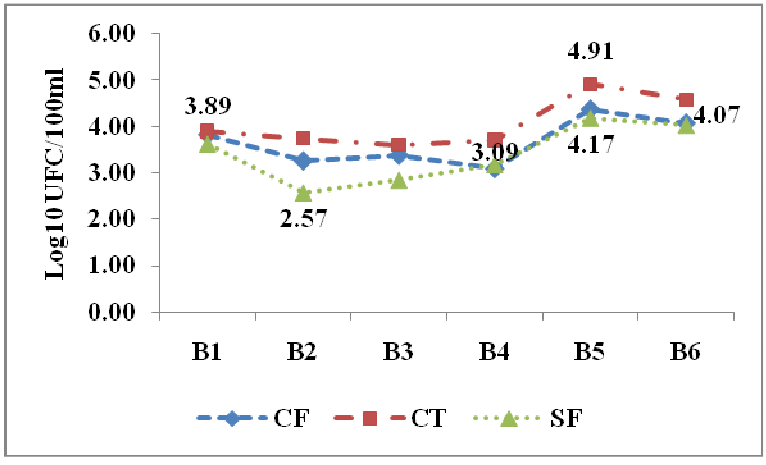

Figure-3
Spatial evolution of bacteriological parameters, fecal coliforms (FC), total coliforms (TC), fecal streptococci (FS)

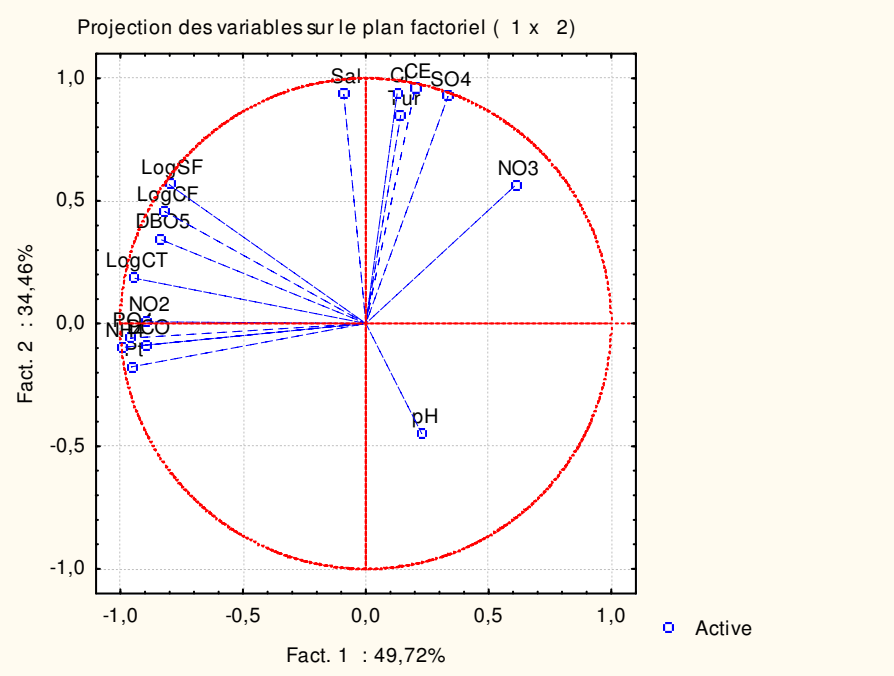

Figure-4
Principal Component Analysis of physicochemical and bacteriological parameters

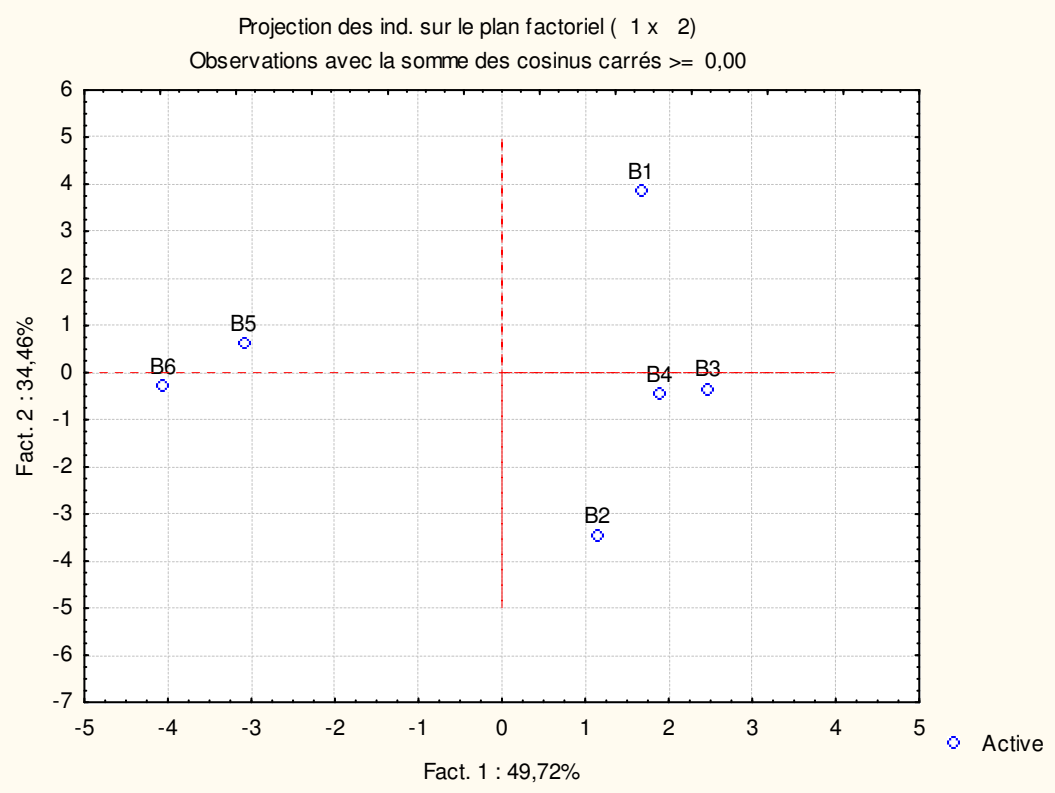

Figure-5
Principal Component Analysis of stations

Table-1
Source of pollution reported by fecal coliform / fecal streptococci

Stations	B1	B2	B3	B4	B5	B6
R=(CF/SF)	1,06	1,27	1,19	0,97	1,05	1,01

R <0,7 mainly or entirely of animal origin; R between 0,7 and 1 mixed animal dominance, R between 1 and 2 uncertain origin; R between 2 and 4 mixed predominantly human, R> 4 source exclusively human.

Table-2
Correlation between the various variables

	pH	CE	Sal	Turb	Pt	PO4	NO3	NO2	NH4	DCO	DBO5	Cl	SO4	CF	CT	SF
pH	1,00															
CE	-0,24	1,00														
Sal	-0,42	**0,92**	1,00													
Turb	-0,73	**0,75**	**0,68**	1,00												
Pt	-0,26	-0,40	-0,10	-0,22	1,00											
PO4	-0,14	-0,26	0,00	-0,20	**0,97**	1,00										
NO3	0,13	**0,67**	0,42	0,46	-0,63	-0,47	1,00									
NO2	-0,14	-0,17	0,13	-0,21	**0,91**	**0,95**	-0,35	1,00								
NH4	-0,20	-0,30	-0,03	-0,20	**0,97**	**0,96**	-0,66	**0,87**	1,00							
DCO	0,13	-0,22	-0,01	-0,36	**0,87**	**0,95**	-0,38	**0,93**	**0,89**	1,00						
DBO5	-0,25	0,22	0,50	0,07	**0,66**	**0,69**	-0,46	**0,68**	**0,78**	**0,68**	1,00					
Cl	-0,18	**0,95**	**0,82**	**0,74**	-0,29	-0,12	**0,75**	-0,06	-0,21	-0,08	0,16	1,00				
SO4	-0,22	**0,98**	**0,85**	**0,76**	-0,49	-0,35	**0,80**	-0,24	-0,43	-0,31	0,04	**0,95**	1,00			
CF	-0,52	0,23	0,41	0,41	**0,71**	**0,74**	-0,31	**0,62**	**0,79**	**0,62**	**0,79**	0,32	0,10	1,00		
CT	-0,27	0,00	0,22	0,05	**0,82**	**0,84**	-0,56	**0,72**	**0,93**	**0,78**	**0,90**	0,05	-0,17	**0,92**	1,00	
SF	-0,31	0,42	**0,63**	0,29	**0,63**	**0,71**	-0,18	**0,70**	**0,74**	**0,69**	**0,93**	0,45	0,27	**0,90**	**0,89**	1,00

Conclusion

This work fits within the framework of the evaluation of physicochemical quality of the Bouskoura river and with the distribution of the indicating germs of a fecal pollution in answer to the various disturbances of the ecosystem. The follow-up of several physicochemical parameters provided us the image of a relatively intense pollution which results in an important organic load with the downstream of the Oued.

However, the report COD/BOD5 industrial discharges Lissassfa (B5) is about 1,43 which gives an effluent more or less readily biodegradable, which requires a purification of these releases before being discharged into the river. Furthermore, the waters of Oued Bouskoura are hard and have a significant a natural mineralization improved of the CE, Cl, Sal and SO4 indicated.

The enumeration of the indicating bacteria of the fecal contamination (CT, CF and SF) and the space distribution of these micro-organisms reflected an intense fecal pollution downstream of wad. The TC, FC and FS are indirectly influenced by physicochemical properties of the Oued. Statistical analysis demonstrated that TC and FC were related to physicochemical factors such as Pt, NH4,

The abundance of the fecal germs varies little from one country side to another, and the recorded values largely exceed the standards of the water intended irrigation.

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