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Study of physico-chemical parameters of water quality in the Kannar river (Stehate- Chefchaouen, Morocco)

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ABSTRACT

Summary In the context of the knowledge of the functioning of estuaries and the evolution of abiotic factors on the basis of the marine dynamics, a study was conducted on the Kannar River.Water samples were collected seasonally during January, February, March, April, May and June 2014. Eight stations have been studied. Monitoring of several parameters showed significant variations. Indeed, the mean temperature of water ranging from 16.62 to 20.04°C, the pH is alkaline from 6.08 to 7.44, dissolved oxygen fluctuated between 3.39 and 5.45 mg/l and conductivity which follows the profile of salinity indicating the degree of mineralization of mean ranging from 277.29 to 691.60 µs/cm.From present investigations we concluded that the quality of most of the water samples under study was suitable for irrigation purpose except in summer season. It was also observed that the water in the year 2014 was of a better quality than on the previous years. Suitable suggestions were made to improve the quality of Kannar river water.

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INTRODUCTION

Estuarine and coastal areas are complex and dynamic aquatic. Coastal water has become a major concern because of its values for socioeconomic development and human health. With the growth of human populations and commercial industries, estuarine water has received large amounts of pollution from a variety of sources such as recreation, fish breeding and the assimilation and transport of pollution effluents through rivers. And more, we are witnessing an expansion and an increase of the industry and agricultural activities, as well as a rapid growth of the Moroccan population [1]. These situations have generated great pressure on the ecosystem, resulting in a decrease of water quality and biodiversity, loss of critical habitats.

Water is an indispensable natural resource on earth. All life including human being depends on water. Due to its unique properties water is of multiple uses for living organism [17,23,8]. Thus, water is a natural resource with limited and uneven distribution in time and space. All forms of life and all human activities are dependent on water. Water resources are of great importance to human life and economy. Lack of water is considered as a limiting factor of socio-economic development of a country [15,20].

The region of Stehate endures a big problem of pollution of the surface waters. This pollution takes various origins: domestic, agricultural and industrial. Indeed, the Kannar basin is located in the Rif field. This area corresponds "to the Mediterranean Morocco", i.e. to the northern part of Morocco who bears the geographical imprint and more geological Mediterranean influence [5,18].

The Kannar River is located in the Atlantic coast (province of Chefchaouen). It has a regime of 'Mediterranean' type, characterized by the opposition of a wet season (November to April), and a dry season (from May to October). It is however tempered by the proximity of the ocean, but this moderating influence is hidden towards inside, by the presence of a plateau which is interposed between the plain and the ocean. The hydrology of the Kannar River, linked to seasonal variations, reflects those of precipitation.

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This river contact between fresh and salt water, is characterized by a dynamic tide we so pushed to focus our study on this river and to study some physical and chemical parameters and their spatial and temporal evolution.

MATERIALS AND METHODS

Study site:

For the study of the hydrology of the Kannar River, several physical and chemical tracers have been the subject of a temporal and spatial monitoring: temperature (air and water), pH, salinity, dissolved oxygen, and conductivity. Five stations selected and visited in Kannar river estuary for four periods as soon as January, February, March, April and May during 2014 (Photo 1).

Photo 1: Map of the study area in Kannar river during 26/02/2014.

Water samples collected at the surface of the water and the various parameters were measured on the ground.

Presentation of sampling stations:

For our study 8 stations distributed along the Kannar river estuary were chosen taking into account various activities identified in the area (Figure 1).

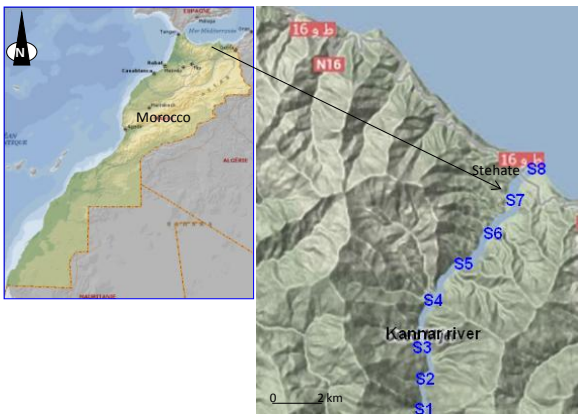

Fig. 1: Site of sample collection (Kannar River in Morocco).

The Kannar River covers an area of 3750 km^2 (Fig. 1). The river is 20 km long, with a fluvial harbor located on the left side, 1 km from the mouth. This harbor is bordered southeastern by an industrial zone and southwestern by Staihate city. The adjacent region, Kannar plain, supports extensive farming activity extending for almost 20,000 ha. The annual average Kannar River output, recorded in the upper sector, is 60 m^3/s, ranging from 0.5 m^3/s (August-September) to 200 m^3/s (January- February). The annual solid flow ranges between 0.2 and 6.106 tons. During the dry period, inputs to the estuary come only from the bordering marshes.

The geographical coordinates of the stations in the Kannar river and their characteristics are presented on table I.

Sampling and sample preparation:

The water samples were collected at the level of each station, during each campaign, from a boat. In outside, the various parameters were measured (Photo 2).

Analysis method:
Air temperature:

The temperature of the air surveys were conducted using a Pulse Oximeter.

Table I: Coordinates of the stations in the Kannar river.

	S1	S2	S3	S4	S5	S6	S7	S8
X	35°18'34"	35°18'47"	35°18'59"	35°19'11"	35°19'24	35°19'36	35°19'47"	35°20'0"
Y	-4°58'46"	-4°58'28"	-4°58'7"	-4°57'47"	-4°57'26"	-4°57'6"	-4°56'47"	-4°56'26"

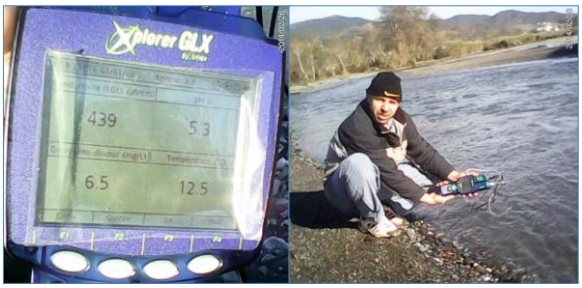

Photo 2: Material used in situ during winter season showing 4 parameters (conductivity, pH, dissolved oxygen and temperature)

Water temperature:

The temperature of the water surveys were conducted using a Mercury thermometer graduated in 1/10 of a degree Celsius.

Potential hydrogen (pH):

The measurements were made using a pH meter Orion Research, Ionalyeser model 607 with specific electrode Orion pH 91-05.

Dissolved oxygen:

Expressed in mg/l, it is a parameter was measured in the field using a Pulse Oximeter ORION Research, Ionalyser model 607 with specific electrode O2.

Conductivity:

The conductivity is measured using a conductimeter.

Water pressure:

Water pressure is measured using a manometer.

RESULTS AND DISCUSSION

Spatiotemporal variation of hydrological parameters during year 2014:

The physico-chemical characteristics of Kannar river water samples of Staihate in north of Morocco are presented in Figure 2.

Temperature:
Air temperature:

The temperature of the air is a very important factor in the determinism biocenotic also by its extreme levels than its diurnal or seasonal variations [4]. At the level of the water, it acts on density, viscosity, solubility of gases including oxygen and carbon dioxide [2]. But a certain threshold, it can play a negative role as soon as organisms by restricting the use of nutrients [10]. Just as most vital chemical reactions are slowed down see arrested by a lowering of the temperature [2].

During the Winter (January) period, we recorded a decrease of temperature of 6°C between S1 and S5, while in Springer (May), the temperature decreased to 7°C (Table II).

The results of Figure 1 showed that the temporal variation of air temperatures in the studied sites, have identical appearance for the entire period of work with the exception the allure of S3. The magnitude of the variation between the campaigns does not exceed the value 27°C.

Table II: Mean concentrations of the air temperature (°C) in all stations of the Kannar river.

	S1	S2	S3	S4	S5	S6	S7	S8
Jan-14	19,12	20,9	21,6	16,1	15,8	21,4	15,4	14,7
Feb-14	20,2	13,14	18,01	17,3	18	22,2	15,2	15,1
Mar-14	21	22,4	19	18,9	18,4	18,5	17,6	18,54
Apr-14	24,6	22	21,8	19,2	16,24	18,6	16	15,32
May-14	25,6	24	23,54	23,64	21,9	19,2	18	17,28

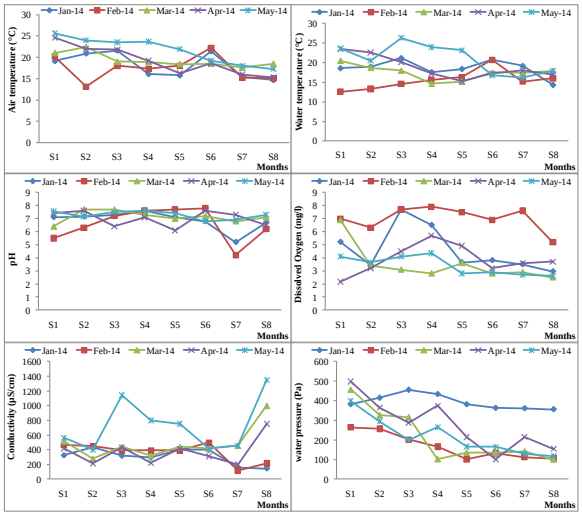

Fig. 2: Concentrations variation of air temperature, water temperature, pH, dissolved oxygen and conductivity in the Kannar river.

Water temperature:

The natural water temperature plays a key role in the distribution of the species also by its extreme levels and its diurnal or seasonal variations. It is an important factor in the life of a river estuary. The normal elevation of this setting is due to a direct input of heat from industries using water as refrigerant. The properties of water affected by temperature and which are important for its quality are: the density and the viscosity, two factors that control the speed of the sediment deposits and the formation of natural stratification, especially in lakes, ponds and the seas, the vapor pressure, so evaporation, the solubility of gases in water and in particular oxygen, thus the variation of the temperature of the water between 13°C and 20°C, causes a decrease in the concentration of oxygen in the order of 14% and finally the rates of chemical and biochemical reactions varied with temperature [2].

We must remember that the three factors that control aquatic environments in general are on the one hand, the illumination, on the other hand temperature and depth. Indeed, if the illumination conditions in the first place the plant and animal life, the temperature adjusts the diffusion of gases (O_2 and CO_2) in water and subsequently influences the process of photosynthesis (Nisbet and Verneau 1970). Therefore this parameter must be known accurately for all samples studied. As shown in Table III, the temperature of the waters of the Kannar River varies between 12.6 and 26.3°C.

Table III: Mean concentrations of water temperature (°C) in all stations of the Kannar river.

	S1	S2	S3	S4	S5	S6	S7	S8
Jan-14	18,6	19	21,2	17,6	18,4	20,7	19,2	14,3
Feb-14	12,6	13,3	14,6	15,6	16,3	20,7	15,2	16
Mar-14	20,5	18,7	18	14,7	15,2	17,5	17,4	17,9
Apr-14	23,5	22,6	20,1	17,2	15,3	17,2	18	17
May-14	23,6	20,5	26,3	23,97	23,18	16,82	16,2	17,9

In the present study, water temperature among the study sites showed higher variation (12.6°C recorded in station 1 – 26.3°C detected in station 3). But, in the Mangrove Ecosystem of Mahanadi River Delta, Odisha in India, water temperature among the study sites showed little variation (24.2°C – 30.9°C) [3].

During the Winter period (January), we recorded a decrease in temperature of 4°C between S1 and S8, while in Springer (May), the temperature decreased by 6°C.

The highest temperatures (26.3°C) are recorded during the months the hottest (May) by the year of 2014, while the (12.6°C) temperatures are recorded during the wet and cold months (February) of the same year.

The temporal variation of water temperatures of the studied sites, have identical appearance for the entire period of work (Figure 1). The amplitude of variation between the campaigns does not exceed in any case 30°C.

For stations in more downstream, the temperature increases by moving away from the mouth. This is due to the decrease of the influence of marine, generally colder waters, and the effect of continentality. This situation was made also in the Loukkos River estuary [8].

Potential hydrogen (pH):

pH of the water summarizes the stability of the balance between the different forms of carbonic acid. It is linked to the system buffer developed by carbonates and bicarbonates. It is a determinant factor in control of the process of relargage and the fixation of the phosphorus by sediment. It depends on the release of carbon dioxide from the atmosphere, the balance of respiratory and photosynthetic metabolism, as well as the origin of waters, the geological nature of the crossing environment and discharges of sewage [13]. It is inseparable from the values of temperature, salinity and the rate of CO_2 [21], thus it has been shown that the mineralization of organic matter causes a decreasing of the pH [11].

In our study, pH values vary between 4.2 (noted in S7) and 7.8 (obtained in S6) during in the winter 2014. This variation is due to the buffering effect of bicarbonate ions, indicating the good potability of the water. This situation was similar in other study detected in Loukkos river estuary [8].

The variation of pH between the campaigns generally exceeds the pH unit except the S7. Indeed, the S7 presents average lower of pH (4.2). However, as it is illustrated in Figure 1, the allure of the curves of temporal variation of the pH for the 8 study stations is very varied and does not follow a regular law.

The waters of the estuary are very anchors. The pH is about 8, due to the buffer system developed by carbonates and bicarbonates that are important in this environment.

The upstream waters are slightly more basic (pH=7) than water near downstream of the mouth mostly at low tide. This observation was made also in the Bouregreg river estuary [6] and the Sebou River estuary [11] in effect at low tide, upstream waters are dependent on freshwater and pollutant mass reduced by the Kannar river resulting in an increase of pH; linked to the degradation of organic matter (Table IV).

Table IV: Mean concentrations of the pH in waters of the Kannar river.

	S1	S2	S3	S4	S5	S6	S7	S8
Jan-14	7,1	7,15	7,3	7,6	7,1	6,8	5,2	6,7
Feb-14	5,5	6,3	7,2	7,6	7,7	7,8	4,2	6,2
Mar-14	6,4	7,7	7,7	7,3	7	7,2	6,8	7,1
Apr-14	7,4	7,6	6,4	7,1	6,1	7,6	7,3	6,5
May-14	7,56	7,16	7,5	7,61	7,4	6,8	6,9	7,3

Dissolved oxygen:

Dissolved Oxygen is a particularly useful parameter for water and is an excellent indicator of quality. Its presence in surface water plays a key role in the self-purification and maintenance of aquatic life. However, its presence in urban water is seen as troublesome due to the possibility of corrosion of metal distributors [19].

Dissolved Oxygen is one of the fundamental factors of life. It enters the composition of atmospheric air with 21%, and represents approximately 35% of the dissolved gas in water at normal pressure [2].

Results temporal, shows a low quantity of dissolved oxygen (2.16 mg/l) was found in station 1 during the month of February 2014 and high concentrations of DO were recorded during the month April (7.9 mg/l) (Figure 1).

The allure of the curves of temporal variation of dissolved oxygen for all stations is identical except the S1 where there is low dissolved oxygen during the month of February 2014 (Table V).

Table V: Mean concentrations of dissolved oxygen (mg/l) in the waters of the Kannar river.

	S1	S2	S3	S4	S5	S6	S7	S8
Jan-14	5,21	3,45	7,7	6,5	3,64	3,8	3,49	2,95
Feb-14	7	6,3	7,7	7,9	7,5	6,9	7,6	5,2
Mar-14	6,9	3,4	3,1	2,8	3,6	2,8	2,9	2,5
Apr-14	2,16	3,2	4,5	5,7	4,9	3,2	3,6	3,7
May-14	4,1	3,65	4,1	4,36	2,8	2,9	2,7	2,6

The highest values being stored at the level of the mouth, submitted the direct influences of oxygenated seawater. The lowest values were found in upstream. This is explained by the pollutant load conveyed by the Loukkos River, mainly at low tide to the ocean. This observation was made also in the Sebou river estuary [7].

Waters of the S2, very near to upstream, subject to a mainly fluvial influence, have relatively high dissolved oxygen levels. This situation could be explained by the absence of organic input of the upstream (guard dam prevents their decent to the mouth) and originally a very important in this deduction fish mortality. This finding was made also by several authors [19].

Conductivity:

The conductivity of water is an indicator of changes in the composition of materials and their overall concentrations. It is proportional to the quality of dissolved ionisable salts [21].

The conductivity informs on the degree of global mineralization of the surface waters. High temperatures affect the conductivity [8]. Natural waters are used as solvent of a considerable number of solutes, which in aqueous solution are either completely associated to ions or partially ionized. High conductivity informs either to normal pH, either the most often a high salinity [12].

The results presented on Table 6 showed that the recorded values oscillate between 117 µs/cm (S7) during the month of February 2014 and 1350 µS/cm (S8) during the month May 2014 (Table VI). Indeed, these values of 117-1350 µS/cm recorded in our study are lower to those reported by Behera *et al*. (2014) in Mangrove Ecosystem of Mahanadi River Delta, Odisha of India which the electrical conductivity was detected of the order 5160–17330 µS/cm.

Table VI: Mean concentrations of the conductivity (µs/cm) in water of the Kannar River.

	S1	S2	S3	S4	S5	S6	S7	S8
Jan-14	325	432	319	294	401,2	400	156	143
Feb-14	464	446	391	389	391	495	117	215
Mar-14	517	279	440	320	438	414	456	1000
Apr-14	418,62	213	430,32	220	415,23	312,48	201,47	750
May-14	560	400	1140	800	750	415	456	1350

The upstream to downstream the conductivity increases gradually. This increase is normal. Indeed, the Kannar river receives at these level releases of rice. For S8, the conductivity is very varied and the values registered in this site are between 143 and 1350 µs/cm. The conductivity decreases gradually during the January period while during the May, there is does increase the conductivity.

Figure 1 shows the curves of variation of conductivity of the raw water of S5. The allure of the curves is not regular. Indeed, for all stations, the allure of the curves is almost identical. It presents a low conductivity in the month April.

Furthermore, temporal variations in S8 and S3 are characterized by a decrease in conductivity mainly during the month of January 2014, while they reach the maximum during the months of May 2014.

Water pressure (hydrostatic):

As a physical parameter, the pressure is considered as the temperature, plays an extremely important role in most sectors. From the point of view of thermodynamics, it is an intensive grander (Table VII).

Table VII: Mean concentrations of water pressure (Pa) in the waters of the Kannar river.

	S1	S2	S3	S4	S5	S6	S7	S8
Jan-14	382	414,5	455,25	433,25	381,25	362,5	361	355,75
Feb-14	264	256,8	201,65	165,5	100,2	132,5	112,04	105,32
Mar-14	456,65	325,65	315,98	100,89	134	135	141	100
Apr-14	498	365	287	375	214,65	100,65	214,87	154,32
May-14	398,47	294,51	200	264,98	165,84	164,95	129,51	117,65

Water pressure found high during the study ranged from 100 Pa (S8 in March) to 498 Pa (S1 in April) (Figure 2).

State of stratification of water and air temperature:

Marked thermal stratification of temperature was detected at the spatial scale (Figure 3).

The increase of temperature in the basin will lead to the increase of evaporation. Therefore, the decrease of precipitation and increase of evaporation have resulted in the decrease of river runoff of the River [25].

The decreasing trend of river runoff of the Kannar River and the increase of temperature were mainly caused by the climate change [26,16,14,8]. Therefore, the results obtained in this research implicates that climate change will affect the water quality including major ion concentrations, conductivity and pH value of rivers [25].

Comparing the different results obtained in the waters of the Kannar river estuary with standards (Table VIII), shows the water quality of the Kannar river estuary is characterized by water temperature without significant difference between the different stations. The mean temperature about 18.31 °C is related to weather conditions and it is less than 30 °C, considered to limit direct discharges into the receiving water. The overall mineral content of water estimated by the analysis of conductivity remains significant along the estuary. Indeed, the water conductivity greater than 1.5 mS/cm makes the water unusable for irrigation of crops. The mean pH remains near neutrality. It is acceptable according to Moroccan standards and the World Health Organization.

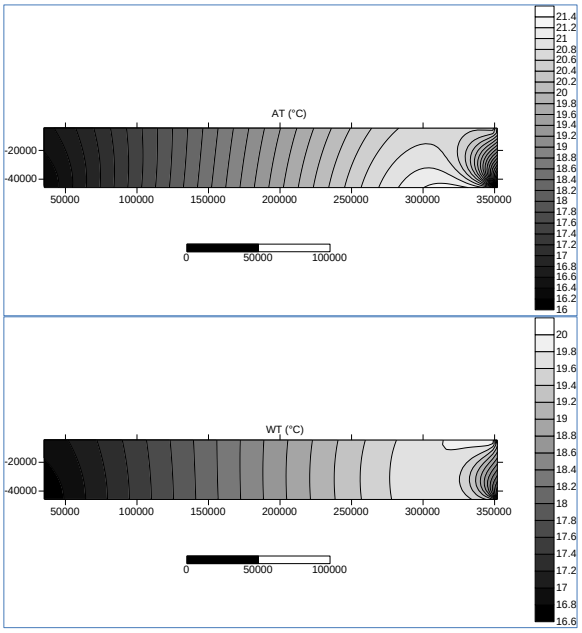

Fig. 3: Vertical profiles of air and water temperature in the Kannar river.

Table VIII: Standards for water quality for human consumption.

Parameters	Results	Standards *	Quality
AT° (° C)	19.31	25 (1)	Good
WT° (°C)	18.31	25 (1)	Good
pH	6.97	6.5−8.5 (2)	Good
DO (mg/L)	4.47	5−8 (2)	Good
WP (Pa)	253.45	35	Good
Ce (µS/cm)	451.85	2.7	Good

*Joint Order of the Equipment Minister and the Minister for Physical Planning, Urban Planning, Habitat and Environment N° 1275-1201 of 10 Sha'ban 1423 (October 17, 2002).

Conclusion:

Through analysis of the mean of the physicochemical parameters of the water in the Kannar river estuary, the current state of water quality, reflects the absence of pollution with significant spatiotemporal variations. From present investigations we concluded that the quality of most of the water samples under study was suitable for irrigation purpose except in summer season.

Given the heavy load produced by industrial activity and urban highly active. Several questions take such as: Absent of a significant and substantial impact on the hydrochemistry of the water system since the concentrations measured in water do not reflect accurately the relative contributions of pollution. This could be explained in the intervention of some physico-chemical phenomena such as precipitation, trapping, settling and storage of pollutants in sediments without neglecting the phenomena of bioaccumulation in fauna and flora. This situation might be acceptable if there were not, storage in sediments and bioaccumulation by plants and animals.

Thus, this study will adopt a better methodological approach to determine the types of pollutants that disrupt the water quality of this ecosystem, for a thorough understanding of the hydrological quality of the site to ensure its protection.

Competing interests:

The authors declare that they have no competing interests.

Authors' contributions:

Mohammed El Morhit carried out the data analysis and drafted the manuscript. Kamilia Hajji provided the conceptual guidance and polished the manuscript. Both authors read and approved the final manuscript.

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