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New simplification into NSF-WQI index to assess El Abid River water quality – Morocco

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ABSTRACT

This research article comprises the calculation of the National Sanitation Foundation-water quality index (NSF-WQI) values for the El Abid River (Morocco) based on twelve physic-chemical and pollution parameters. Then, it defines a new simplified index WQI_{min} based on parameters that are easy to measure in the laboratory or in the field. This simplification of the NSF-WQI parameters is based on principal component analysis, to reduce their associated analytical costs. Compared to NSF-WQI, similar spatiotemporal trends in water quality were obtained by WQI_{min} ($R^2 = 0.68$). The WQI_{min} reveals that during spring, autumn and winter (2016–2017) the quality in the Bin El Ouidane is good upstream, whilst it is undergoing a severe degradation into poor and very-poor-quality status in the downstream section, caused by high population rate and its pollution load coming from a polluted shallow aquifer. In summer when the flow discharge is low, the quality in the upper section is poor, whilst in the downstream section (from Bin El Ouidane to the outlet) it is decreasing to very-poor-quality status ($WQI_{min} = 89.57$). In conclusion, the quality status in the downstream section is alarming and needs urgent intervention. The new simplified WQI_{min} adequately reflects changes in El Abid River water quality using fewer parameters and reducing associated analytical charges.

Keywords: El Abid River; Principal component analysis; Simplified NSF-WQI; Water quality

1. Introduction

Water resources quality is one of the great environmental issues that are demanding huge efforts and amounts of money from governments in the last five decades, to ameliorate its quality and reduce its pollution loads [1,2]. These issues are linked to anthropogenic activities that are affecting river quality on a global scale. In many cases, these issues need to be fully quantified, whilst our ability to understand their size is reduced by limited data sets on a long period of time, and current methods that describe water quality trends, leading to a lack of better knowledge about global river quality [3,4].

Former methods were based on comparing laboratory results with existing local standards, using the same coefficient or importance for all parameters. In many cases, these approaches allow contamination source identification and legal compliance verification. However, they do not give an

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exact view of the overall water quality status. As an example, a water sample which contains six components in levels 5% higher-than-permissible (hence objectionable) pH, total hardness (TH), chloride, sulfate, iron and sodium – may not be as harmful to drinking as another sample with just one constituent, mercury, at 5% higher-than-permissible [5].

To ameliorate these former method limitations, some researchers have applied mathematical computational indices (defined as water quality index (WQI)) to communicate information about water quality trends in an easy manner [6]. These indices provide a single number (like a grade) that expresses overall water quality based on a combination of measured parameters. These indices solve the syndrome of 'data-rich but information-poor', referring to disagreement on the usability of available data between those who produce it in the laboratory and decision-makers who apply it [7,8].

The first WQI attempt was made by Horton [9], selecting and weighting water quality parameters for an aggregation function. Then, U.S. National Sanitation Foundation (NSF) revised Horton's [9] WQI by using Delphi techniques, resulting in the NSF-WQI. This NSF-WQI has been used extensively all over the world, and summarises the quality results in a 100-point scale, using nine parameters [10–13].

Over the years, many studies have attempted to ameliorate NSF-WQI accuracy and suitability for each study area by assuming and introducing other quality parameters [14,15]. For example, 18 parameters were used to assess Bagmati River [16], 20 water quality parameters at Suquı'ıa River, then simplified to only three revealing parameters [6].

Despite a plethora of indices that have been used and developed across the world, it is not possible to decide which index is the best to employ or even to select a list of ten best indices [17]. One does find that some indices are more popular than others, such as NSF-WQI and the Canadian Council of Ministers of the Environment 'CCMEWQI' developed 31 y after NSF-WQI [18,19], which are used not only in their country of origin but also in several other countries spanning several continents [20].

These numerous developed WQIs found in the scientific literature were based on 'crisp' and 'deterministic' mathematical treatment of water quality data. The advancements of these WQIs were aimed at enhancing the objectivity (in the choice of representative parameters and assignment of weighing), sensitivity (to changes in water quality), clarity (in showing a water source as bad, fair, good, very good, etc), and reach (appropriateness for a larger number of regions and types of water use) of the indices. Indeed, a modification into the common indices such as NSF-WQI should take into account local particularities such as anthropogenic activities, geology, river geometry and others, then decide which parameters are irreplaceable [14,21].

Towards the same objectives, using collected measurement data from 1 y, 2016–2017, we aimed in this research article to introduce a simplification into NSF-WQI to ensure a better quality evaluation of El Abid River, and to minimize associated analytical costs of all deployed parameters for each sample. However, this NSF-WQI simplification ensure keeping pertinent parameters that govern the quality variation in El Abid River.

2. Materials and methods

2.1. Study area

El Abid River, located in the northern central part of Morocco, with a 638 km length, is the most important Oum Er-Rbia tributary besides the Tassouat River (Fig. 1). Its basin is mainly located in the High Atlas Mountains, occupying a total surface of 8,041 km^2, with about 13.39% of the plain area (1,238 km^2) and 84.61% of mountain area (6,803 km^2).

The geology of El Abid River is characterized by sedimentary rock ranging from Mesozoic formations (Jurassic sandstone and limestone) in the mountainous part to Mio-Plio-Quaternary sediments in the plains area (gravels, sands and lacustrine limestone). The area is affected by numerous faults and fractures; the most important is the so-called North Atlasic collision.

The area is characterized by a semi-arid climate and is marked by seasonal contrasting climate variability [22]. The rainfall average is 260 mm/y in the downstream section and upper to 700 mm/y in the mountain regions with a seasonal snowpack effect [23]. The annual average temperature is about 17°C, with a small difference between downstream and upstream sections of Bin El Ouidane Reservoir [24].

According to the High Planning Commission 2014, the population of the study area is estimated as 13,990 inhabitants [25]. Based on the Moroccan average rate (80 L/person/d, this population can generate 466 m^3/h of polluting liquid load poured into degraded septic tanks in each agglomerated center. This volume is treated, in part, by three wastewater treatment plants (Azilal, Ouaouizeght, and Aghbala) [26].

2.2. Methods

2.2.1. Quality data analysis

Water samples were collected along El Abid River to characterize its spatial and temporal variability in 13 locations over a 1 y period, from the beginning of March (2016) through the end of February (2017). These surveys were made on a monthly basis to check all acquired phenomena during the year and to eliminate cases where punctual pollution is anticipated. The sampling locations were selected to represent quality status upstream and downstream to each city. The sampling site names were derived from the nearest city; their details and locations are shown in Fig. 2.

Various physicochemical parameter analyses were done in the Oum Er-Rbia Hydraulic Basin Agency Laboratory according to Moroccan standard methods [27]. A set of eleven commonly used water quality parameters were measured using volumetric titration methods (chloride Cl^-, total alkalinity TA, TH), spectrophotometer (sulfate SO_4^-, total phosphate PO_4^{3-}, nitrates NO_3^-), biochemical oxygen demand (BOD), and filtration membrane to measure total suspended solids (TSS). On the other hand, the pH, electrical conductivity (EC), water temperature (T) and dissolved oxygen (DO) were measured in situ. In addition, we used a dataset measured in Bin El Ouidane Reservoir and near Bzou City by Oum Er-Rbia Hydraulic Basin Agency (ABHOER) from 2000 to 2018.

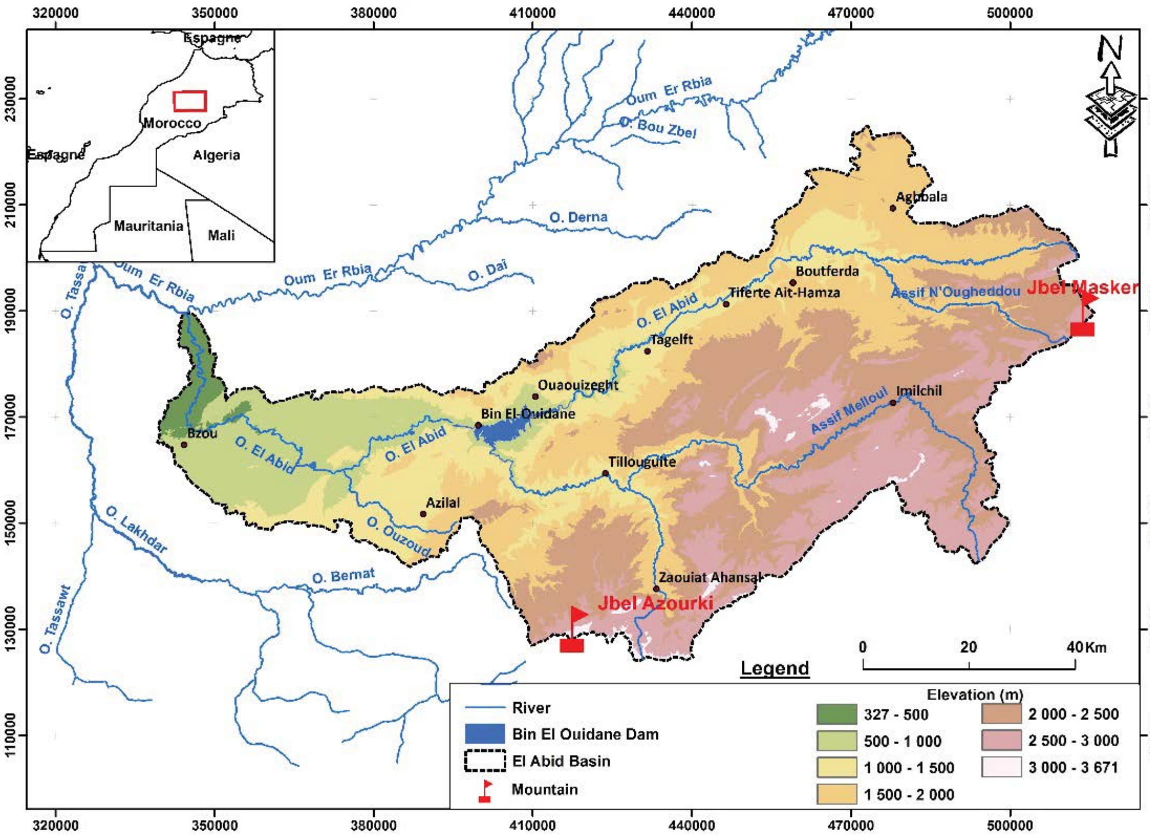

Fig. 1. Location, hydrographic network and elevation of the El Abid basin.

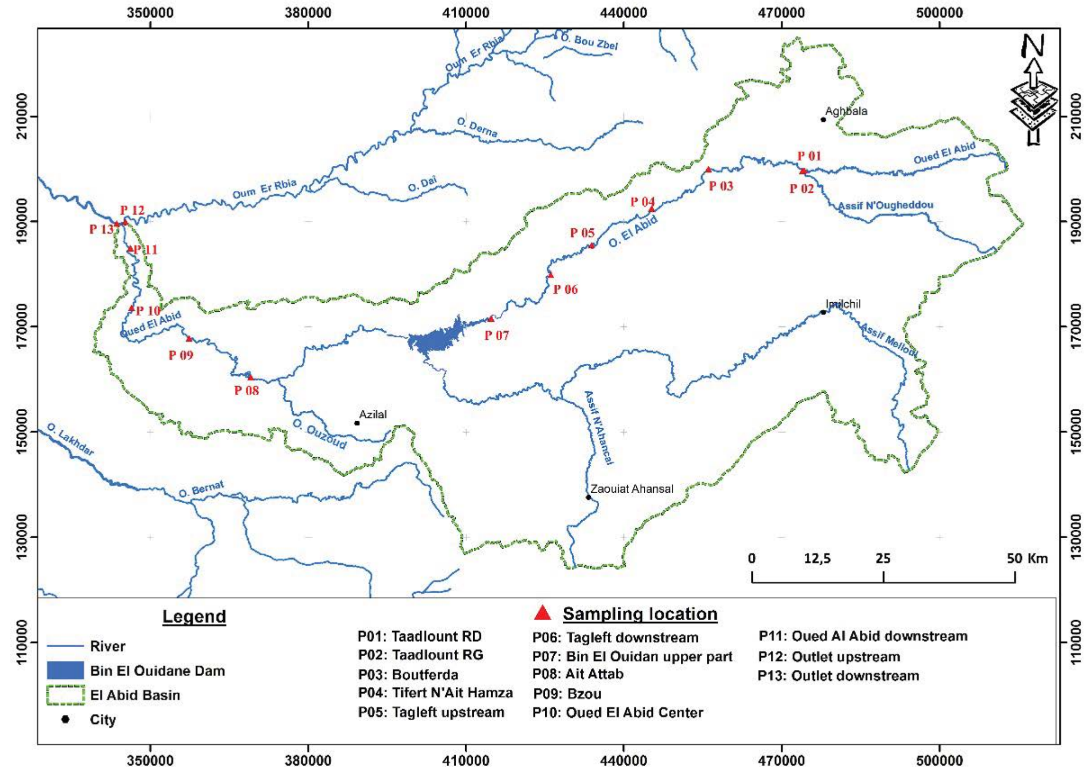

Fig. 2. Sampling points map showing the location and the name of each surface water sample.

Based on analytic results, NSF-WQI was calculated for each sample. This index classifies quality status on a 0 to above 100 scales, with the 76–100 interval representing a very-poor-quality status, 0%–25% represents an excellent status, whilst values above 100, represent unsuitable water for drinking and fish culture (Table 1). NSF-WQI calculation is made by the weighted arithmetic index method [28], using Eq. (1):

$$\text{NSF}-\text{WQI}=\frac{\sum_{n=1}^{n} q_n W_n}{\sum_{n=1}^{n} W_n} \tag{1}$$

where q_n is a quality rating that is reflecting parameters relative value with standard permissible value (Rao et al. [29]). The q_n is calculated using ideal value (V_i) that is equal to zero $V_i = 0$, except for pH ($V_i = 7$), T ($V_i = 25$) and DO ($V_i = 14.6$ mg/L), observed value (V_n), measured parameter standard permissible value (S_n).

$$q_n = 100V_n - V_i / S_n - V_i \tag{2}$$

W_n is the unit weight of nth water quality parameter [30], calculated using Eq. (3):

$$W_n = \frac{K}{S_n} \tag{3}$$

where K is the proportionality constant calculated by Eq. (4):

$$k = \frac{1}{\left(\sum 1/\left(S_n = 1,2,\ldots,n\right)\right)} \tag{4}$$

2.2.2. NSF-WQI simplification using the principal component analysis method

The simplifications made on the parameters used to calculate NSF-WQI were aiming to ensure associated analytical charge minimization when characterizing water quality at different stations, whilst keeping a WQI evaluation with the same precision. This simplification will ensure passing from the 12 parameters used in NSF-WQI calculation to a reduced number, thus a quick result instead of waiting to complete all analyses in the laboratory.

This simplification attempts to use relevant parameters that explain the water quality trend in El Abid River. For this reason, the collected data and monitoring conducted by ABHOER (from 2000 to 2018) in the study area were statistically analyzed to check the parameters' correlations. The principal component analysis method (PCA) was used as a factorial analysis to group individual parameter components by their loading plots for the investigated contaminated sites and to obtain appreciable data reduction for analysis and decisions [31]. This PCA method is useful when a large amount of quantitative data is available and needs interpretation and processing to synthesize its information [32].

The Kaiser-Meyer-Olkin (KMO) test was used to measure how suitable the collected data was factor analysis. This test measures sampling adequacy for each variable in the model and for the complete model [33]. The factorial analysis was performed using open-source *R* software.

3. Results and discussion

3.1. Water quality status and NSF-WQI results

Twelve parameters used in NSF-WQI calculation are summarised statistically in Table 2 in seasonal average form.

Based on Moroccan standards, DO results were generally fair to good, except at P13 (outlet downstream) where it was equal to 2.20 mg/L during winter (December), which is classified as bad quality. In P06 (Tagleft downstream) during April, the DO concentration was 2.80 mg/L.

BOD results were classified as excellent quality status during all measurement periods. Concerning the NO_3^- variation, it is alarming, and exceeded 15 mg/L in many cases and reached 25.91 mg/L. Those concentrations are very high and hazardous for human consumption. Generally, the rest of the parameters ranged from fair to good quality.

The NSF-WQI calculation involves unit-weighting (W_n) estimation for each physicochemical parameter considered. By assigning unit-weights, all parameters are transformed into a common scale [34]. Table 3 shows the unit weights and standards derived from Moroccan standards that were used [27]. The maximum weight used was 0.366, assigned to BOD, followed by 0.266 (DO), thus indicating their significance in water quality assessment [35].

The NSF-WQI calculation results (Fig. 3) showed that the quality from P01 to P07 during spring, winter and autumn was good generally (NSF-WQI varying from 32 to 42), but

Table 1
WQI range, status and possible usage of the water sample

WQI	Water quality status	Possible usage
0–25	Excellent	Drinking, irrigation and industrial
26–50	Good	Drinking, irrigation and industrial
51–75	Poor	Irrigation and industrial
76–100	Very poor	Irrigation
Above 100	Unsuitable for drinking and fish culture	Proper treatment required before use

Table 2
Statistical summary of water quality parameters. Values are expressed in mean ± standard deviation and the minimum and maximum values in round brackets

Parameter	Winter	Spring	Summer	Autumn
pH	8.11 ± 0.33 (7.65 – 8.66)	7.94 ± 0.23 (7.22 – 8.30)	7.73 ± 0.13 (7.45 – 7.94)	7.84 ± 0.13 (7.51 – 8.04)
EC (μS/cm)	825.82 ± 425.22 (272 – 1721)	881.55 ± 381.24 (420 – 1,876)	1,152.44 ± 565 (464 – 2,200)	982.53 ± 456.20 (388 – 2,030)
T (°C)	12.94 ± 3.93 (5 – 19)	20.34 ± 7.52 (4 – 32)	25.74 ± 4.31 (18 – 32)	17.33 ± 4.91 (10 – 26)
TSS (mg/L)	844.29 ± 2,337.48 (1.60 – 13,204)	294.52 ± 406.39 (10 – 1,425)	56.27 ± 52.96 (3 – 228)	1,843.92 ± 2,274.18 (15 – 7,765)
TH (mg/L)	29.97 ± 9.17 (17.20 – 57)	91.34 ± 27.29 (29.40 – 152.70)	130.17 ± 83.94 (64.72 – 403.14)	78.77 ± 85.72 (19.60 – 396.92)
Cl^- (mg/L)	133.29 ± 136.15 (10.65 – 443.75)	94.48 ± 90.59 (7.10 – 301.75)	118.44 ± 88.23 (14.20 – 302.64)	131.15 ± 105.69 (21.30 – 305.30)
DO (mg/L)	6.80 ± 1.43 (2.20 – 9.80)	6.80 ± 1.58 (2.80 – 9.60)	5.70 ± 1.13 (4.30 – 9.80)	7.11 ± 2.01 (3.70 – 12.70)
BOD (mg/L)	1.03 ± 0.55 (0.13 – 2.29)	0.87 ± 0.43 (0.39 – 2.01)	0.86 ± 0.36 (0.39 – 1.55)	1.47 ± 0.45 (0.73 – 2.24)
SO_4^- (mg/L)	74.70 ± 38.70 (18.06 – 204.14)	104.32 ± 67.56 (14.73 – 338.12)	100.32 ± 85.58 (24.62 – 478.98)	171.54 ± 203.07 (24.83 – 918.97)
TA (mg/L)	0.60 ± 0.82 (0 – 3)	230.56 ± 117.71 (0.50 – 634.30)	245.49 ± 72.51 (133.30 – 417.85)	91.87 ± 125.58 (0 – 457.50)
NO_3^- (mg/L)	7.57 ± 7.20 (0.02 – 19)	8.70 ± 3.59 (0.38 – 16.40)	9.72 ± 4.77 (2.33 – 25.91)	5.12 ± 4.46 (0.04 – 16.40)
PO_4^{3-} (mg/L)	0.19 ± 0.28 (0.01 – 1.21)	0.37 ± 0.45 (0.03 – 1.75)	0.18 ± 0.19 (0 – 0.75)	0.91 ± 0.89 (0 – 3.40)

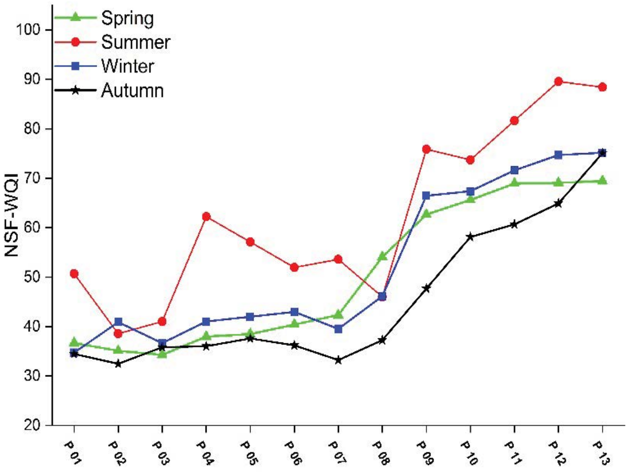

Fig. 3. NSF-WQI seasonal variation from the beginning of March (2016) through the end of February (2017).

during summer the majority of the measured points were poor in status (P01, P04, P05, P06, P07; NSF-WQI from 50–62) and good in P02 and P03. These results are linked to the absence of industry, low agricultural activity, and very low population rate since the area is more or less mountainous [36,37]. During summer, the low flow discharge and some touristic activity could be the cause of this deterioration in the upstream section.

During spring, from P08 to the outlet, the quality is poor (NSF-WQI 54–59); in summer, it arrives into the very-poor-quality status from P09 to the outlet (NSF-WQI 73–89). During autumn and winter, the quality is poor from P09 to P12 (NSF-WQI 58–74); in P13 during both seasons the NSF-WQI is equal to 75, meaning the quality status is very poor. This degradation in the quality status from P08 to the outlet may be explained by an exchange between the river and the polluted shallow aquifer, by the direct discharge of wastewater and by intense agricultural activity (since this section is located in Tadla Plain boundaries). This process has occurred generally when the piezometric level of the shallow aquifer was higher than that of the river, thus all pollution contained in the shallow aquifer was transported into the El Abid River [26]. The flow discharge diminution caused by Bin El Ouidane Reservoir could affect the quality status in the downstream section by preventing the dilution of contaminants [38,39].

3.2. PCA results and proposed NSF-WQI simplification

The KMO test results revealed that our dataset is suitable for the PCA analysis method, and explain an average of 0.75 in precision. These PCA results (Table 4) showed that factor 1 axis explains 38.06% of the total variance in the data set. The spreading along the horizontal axis is mainly due to the variance in the parameter values for EC (0.535), Cl^- (0.617), BOD (0.744), TA (0.425) and PO_4^{3-} (0.701). The factor 2 axis, which is heavily influenced by TH (0.526), TSS (0.448) and *T* (0.410), explains an additional 25.788% of the total variance. The spreading observed along the axis for factor 3 (17.23%) is due to DO variation (0.775). The three

Table 3
Standard permissible value (S_n), ideal value (V_i), and relative unit weights (W_n) used in NSF-WQI calculation

Parameter	S_n	V_i	W_n
pH	7.7	7	0.017
EC	500	0	0.121
T	30	25	0.046
TSS	500	0	0.003
TH	300	0	0.006
Cl^-	250	0	0.007
DO	5	14.6	0.266
BOD	5	0	0.366
SO_4^-	150	0	0.012
TA	120	0	0.015
NO_3^-	25	0	0.122
PO_4^{3-}	5	0	0.019
ΣW_n			1.002

Table 4
Eigenvalues and factor loadings from the principal component analysis

	Factor 1	Factor 2	Factor 3
Eigenvalue	3.968	2.495	2.069
Variability (%)	38.066	25.788	17.239
Cumulative (%)	38.066	63.854	81.092
	Factor loadings		
pH	0.172	0.066	0.046
EC	0.535	0.347	0.008
T	0.279	0.410	0.085
TSS	0.104	0.448	0.302
TH	0.199	0.526	0.185
Cl^-	0.617	0.245	0.004
DO	0.001	0.041	0.775
BOD	0.744	0.004	0.003
SO_4^-	0.143	0.152	0.186
TA	0.425	0.244	0.048
NO_3^-	0.048	0.004	0.421
PO_4^{3-}	0.701	0.008	0.006

factors together explain 81.092% of the original dataset variance.

By plotting parameters only on two factors' axes (factors 1 and 2) (Fig. 3), we can distinguish between four groups of parameters that are well correlated. Group 1 (T, EC, Cl^-), group 2 (TA, TH), group 3 (BOD, PO_4^{3-}), and group 4 (TSS, SO_4^-, pH, DO). The NO_3^- parameter is not governed by either of these factors (1 or 2). The values for EC, Cl^-, BOD, TA and PO_4^{3-} are highly correlated according to factor 1, whilst TH, TSS and T are correlated in factor 2 (Table 4), it seems well worth investigating the elimination of one or several of these parameters impacts on the NSF-WQI results. As can be seen from Table 4, the above-mentioned parameters have similar loading values in PCA factors 1 and 2.

On the basis of Fig. 4, it can be seen that sampling stations P12 and P13 were strongly influenced by EC, Cl^- concentration and T variation. This was caused by the downstream geology, which is characterized by evaporating formations and high temperatures due to its location in Tadla Plain [24,26]. Stations P03, P06 and P11 were influenced by the DO, TSS, SO_4^- concentrations and pH. Stations P04 and P08 were influenced in opposite ways by NO_3^- and DO concentration. However, the rest of the sampling points were randomly influenced by different parameters.

The simplification of the used parameters was made by using Pearson's low correlation, to determine the linear correlation between the used parameters (Table 5). This correlation showed that pH is negatively correlated with DO ($R = -0.571$), EC with T and Cl^- ($R = 0.694$ and 0.958, respectively), T with Cl^- ($R = 0.581$), TA with TH ($R = 0.702$), PO_4^{3-} with Cl^- and BOD ($R = 0.55$ and 0.852, respectively), and Cl^- with BOD ($R = 0.596$).

Based on the PCA and Pearson correlation results, a first proposal (WQI_{min}) was made by eliminating Cl^- and T for their high correlation with EC and BOD, DO for its correlation with pH, and TSS and TA due to their correlations with TH. These simplifications have taken into consideration the simplicity, rapidity and chemicals used in the analyses. The eliminated parameters' relative unit weights (W_n) were adjusted and added to the corresponding correlated parameters (Table 6). Noted that this correlation analysis was done on all collected data.

The new weight unit used (Table 6) is characterized by BOD as the highest weighting unit (0.42) followed by NO_3^- and TH. This high value attributed to BOD is for its important role in water quality characterization and pollution determination [40].

Comparing WQI_{min} and NSF-WQI results (Fig. 5), they explain close values in terms of precision ($R^2 = 0.65$; Pearson's correlation = 0.81; root mean square error (RMSE) = 3.96). Fig. 5 shows that when the NSF-WQI is above 100, our new simplified index gives an underestimation of quality status. By checking the origin of these high values in NSF-WQI, we noticed that the concentrations of Cl^- were very high (e.g., 443.75 mg/L during winter in P12) compared to other sampling locations and periods, in which it was equal to an average of 94 mg/L (during spring). When we eliminate this parameter, our new simplified index automatically gives underestimated values of the quality status. Noting that only some (i.e., not all) of the samples and measurement periods are slightly affected by our simplification in NSF-WQI.

In qualitative terms, NSF-WQI and WQI_{min} seasonal results are generally near one another in their corresponding status values. During spring, autumn and winter seasons (Figs. 6a, c and d), both indices fit well in general trends, but from P01 through P07 our simplified index gives a small overestimation, whilst from P08 through the outlet, a slight underestimation. As mentioned above, due to evaporate formations in the downstream section, the geology influences the concentration of Cl^-, and when eliminating this parameter from WQI_{min} calculation, it causes a slight underestimation in quality results. In the upstream section, where the Cl^- concentration is low, the index gives a small overestimation of the quality status.

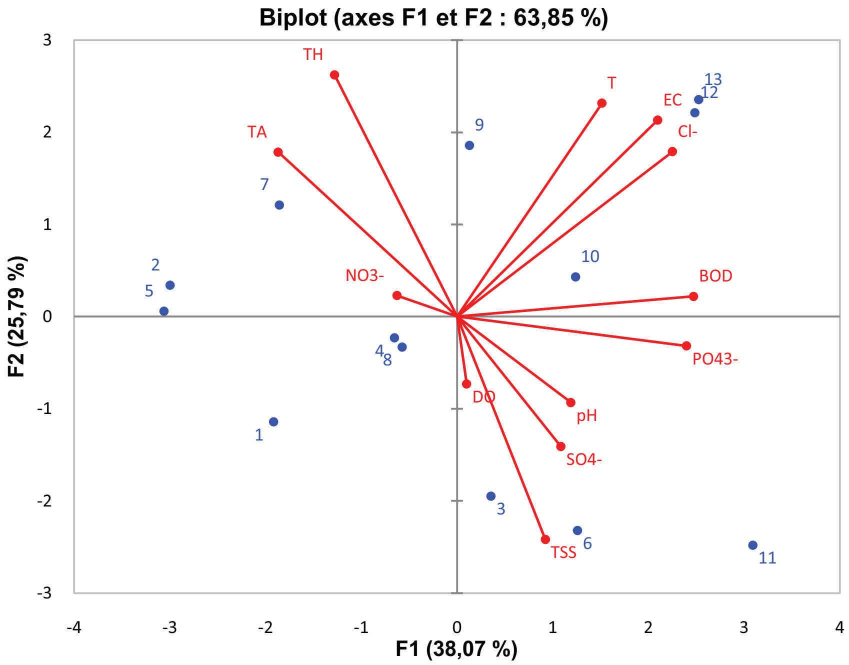

Fig. 4. The used NSF-WQI parameters bi-plot on factors 1/2, and influenced sampling location by parameters variation.

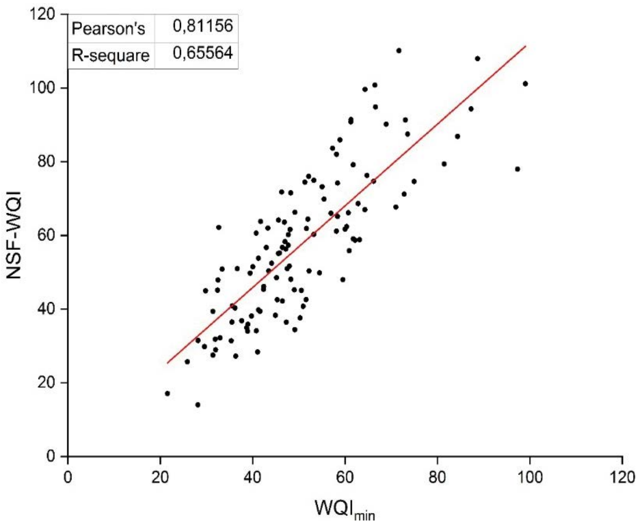

Fig. 5. Correlation between NSF-WQI and WQI$_{min}$ using all measurement data.

Concerning summer comparison (Fig. 6b), the simplified index underestimates the NSF-WQI results in all sampling locations. In this period when the flow discharge is low the eliminated parameter's average concentration is slightly higher compared to other seasons, and even water temperature is significantly more important than in another period. These two parameters could affect the results obtained by the simplified index. The maximum difference was observed in P12 (NSF-WQI = 89.57, WQI$_{min}$ = 64.73), and the average difference between both indices in this summer season was 11.47.

4. Conclusions

A WQI is a helpful way to assess and manage water quality, instead of the traditional method based on standard grids. The present investigation represents the first of its type undertaken for the El Abid River, to characterize its spatiotemporal water quality during the period of March 2016 through February 2017. This case study provides valuable insight into the status of the overall suitability of this river water based on NSF-WQI and new simplified index WQI$_{min}$ values It highlights a new simplification of the list of parameters used in NSF-WQI (12 parameters) to become easier, retaining only the pertinent parameters that describe the quality status in El Abid River. This simplification made using PCA analysis is presented as WQI$_{min}$ and employed only six parameters (pH, EC, TH, BOD, SO$_4^-$ and NO$_3^-$).

The NSF-WQI and proposed index WQI$_{min}$ were verified according to Moroccan standards as a useful tool for assessing and classifying spatial and temporal changes in water quality. Based on these two indices, El Abid River is subjected to a qualitative degradation of its water quality in the downstream section, starting from the town Ait Attab to the outlet. This degradation is linked to the exchange process between the shallow aquifer, polluted by intense agricultural activity and near agglomerations liquid discharge, and the river. The upstream section from P01 to P07 is generally of good quality except during summer when the quality is poor because of the river's low flow discharge and high touristic activity levels.

The new proposed index WQI$_{min}$ is an asset to existing characterization methods for surface water quality and seeks to minimize as much as possible the analytical cost of standard NSF-WQI. However, the methods and results presented in this research also provide a baseline for future monitoring

Table 5
Pearson's correlation between used parameters in NSF-WQI

	pH	EC	*T*	TSS	TH	Cl^-	DO	BOD	SO_4^-	TA	NO_3^-	PO_4^{3-}
pH	1	0.078	–0.359	–0.102	–0.273	0.173	–0.571	–0.027	0.046	–0.279	–0.138	–0.066
EC		1	0.694	–0.269	0.169	0.958	–0.050	0.547	0.143	–0.253	0.067	0.448
T			1	–0.111	0.321	0.581	0.159	0.497	0.187	0.035	–0.090	0.427
TSS				1	–0.553	–0.199	0.333	0.406	0.190	–0.346	0.176	0.520
TH					1	–0.003	0.245	–0.404	–0.172	0.702	0.409	–0.487
Cl^-						1	–0.160	0.596	0.074	–0.334	–0.059	0.550
DO							1	0.045	0.509	0.018	0.346	0.072
BOD								1	0.081	–0.426	–0.255	0.852
SO_4^-									1	–0.413	–0.082	0.149
TA										1	0.265	–0.372
NO_3^-											1	–0.151
PO_4^{3-}												1

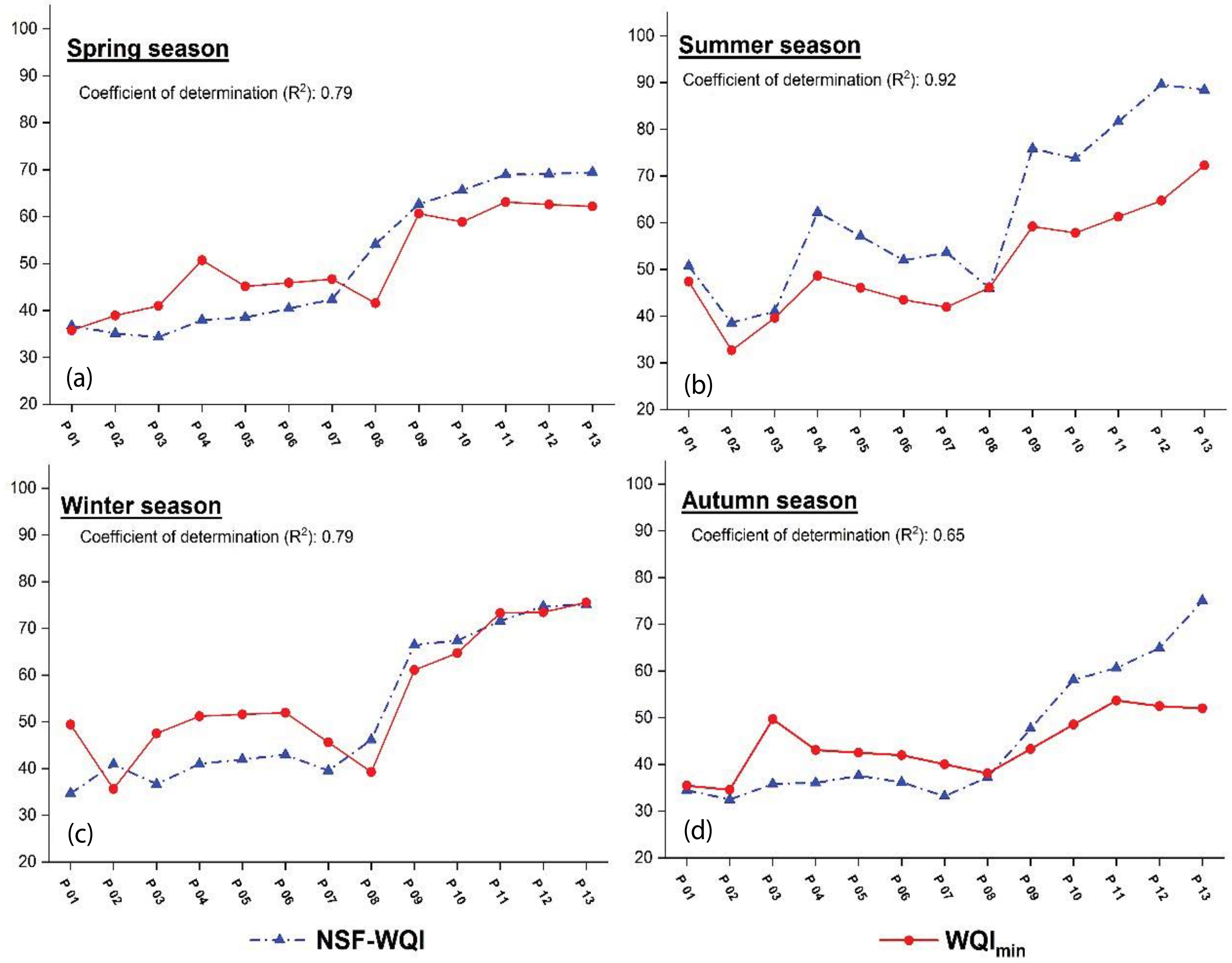

Fig. 6. Seasonal comparison between simplified index WQI_{min} and NSF-WQI (a) spring, (b) summer, (c) winter and autumn season.

Table 6
Adjusted weight unit W_n employed in WQI_{min} calculation

Parameter	W_n
pH	0.083
EC (μS/cm)	0.085
TH (mg/L)	0.125
BOD (mg/L)	0.420
SO_4^- (mg/L)	0.092
NO_3^- (mg/L)	0.222
ΣW_n	1.027

in El Abid River. They revealed that water pollution needs continuous implementation for sustainable management of this river.

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