IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 16, Issue 2 Ser. II (February 2022), PP 12-22
www.iosrjournals.org

Understanding the multivariate process controlling the long term use of the conventional and unconventional resources in the Tunisian Oasis agro-systems

Nawel Meftahi[1], Latifa Dhaouadi[1,2], Houda Besser[3] , Nissaf karbout[1], Mohamed Moussa[1]

[1]*Ermology and combating Desertification Laboratory, Institute of arid regions, Mednine, Tunisia*
[2]*Regional Center of Research in Oasis Agriculture of Degueche-Tozeur, Tunisia*
[3]*Research Unit of Geo-systems, Geo-resources and Geo-environments (UR3G), Department of Earth Sciences, Faculty of Sciences of Gabes, City Campus Erriadh-Zirig, 6072 Gabes, Tunisia*

Abstract
The dynamic behavior of water composition within hydrogeological system and along drainage network coupled with uncontrolled released quantity to the environment represents a main constraint challenging the evaluation of water suitability for particular uses as well as the reuse these resources in irrigation. The efficiency of this operation and the control of the performance of this runoff are often elusive in practice. In this context, the present study aims to evaluate the opportunities for improving water management and drainage water recycle and makes advances in understanding the multivariate process controlling the long term use of the conventional and unconventional resources in southern Tunisia .

The preliminary analysis of water quantity and quality was performed by collecting 10 samples from water wells and 12 from drainage network. Besides to physic-chemical characterization, the potential usability of these resources is evaluated according to the in control study of reuse process as capable to produce water that satisfies irrigation water quality requirements. The results indicate that both resource are in control but not capable to satisfy the needed demands within the required intervals of quality and quantity. The unpredictable behavior of these resources for short and long term use threatens the safe use of these resources. Thus, the continuous use of the current irrigation water and the potential resources to overcome water shortage in hot dry areas of southwestern Tunisia require operational, technical, engineering action and management plans. To sustain safe process, the inefficiency of the used water plans should be based on the inappropriate balance between leaching fraction, applied water quantities, relative crops and water salinity.

Keywords: *drainage water reuse, safe environmental control, capability process, management, southern Tunisia*

Date of Submission: 10-02-2022 Date of Acceptance: 25-02-2022

I. Introduction

Unconventional water resources use recycled drainage water is a practical method with permanent supply if no harmful impacts can be impact human health and the surrounding environmental. It becomes essential resources besides to conventional water resources to supply the growing needs of economic activities especially irrigation during the frequent dry periods. Besides to reduced available volumes, the quality of the used resources represents a main factor constraining their potential use especially for long term. Thus, irrigation waters either drainage water or water well quality management is required for its selection as a supplementary resource for permanent and sustainable use. This evaluation hinges on a number of specifications, namely cultivated crop, irrigation methods, economic benefits, Additionally, the dynamic spatio-temporal evolution of the current used resources and the supplementary unconventional alternatives should be manageable to sustain fruitful production. Thus, a systematic monitoring involving the inspection of water quality of the collected runoff and the efficiency and the influence of different management process as well as the reuse practices is of paramount importance.

In hot dray areas, however, the initially scarce low renewable water resources are escalating pressure, given the growing population and expansion development of water dependent economies and the unpredictable climate variability. Thus, conserving water for sustainable use is the only way forward. As the major concern of water of about 75% to 80% of agricultural water management should make the major contribution for water security at a lower environmental burden (FAO 2007; Shaban 2014; Besser et al. 2017, 2019; 2021; Dhaouadi et al. 2020, Dhaouadi et al. 2021). Sustaining development with better harvest and less water to promote water optimization practices relies principally on an accurate evaluation of water quality and quantity evolution their suitability for uses and the sensitive characteristics of the cultivated crops and encompassing everything from well implementation to harvesting and sealing. This agricultural paradox of safety feeding a growing population while conserving precious resources as water on a limited amount of farmland requires an efficient management flexible to take into account the variability of different key parameters. Water conservation management in consequence should be based on the evaluation of the dynamic evolution of water quality and quantity to develop the required techniques and tools of development. Quality suitability for agricultural uses and engineering process relative to the spatio-temporal evolution is a decisive factor limiting the use of water resources and inhibit safe advanced techniques agricultural production.

In southern Tunisia, a region devoted principally for agriculture which sustains economic pressure and local population livelihood for more than 284, 000 citizens, the continuous use of aquifers and the reuse of the recycled drainage water as a primary resource for agricultural development in Southwestern Tunisia requires the development of management model helping regulating drainage water reuse and eliminate or at least reduce environmental damages and health risks at safer levels (Besser et al. 2017, 2019). The evaluation of different aspects to enhance the development of the agro-systems is primordial namely water needs from conventional and non conventional resources. However, the issues related to non conventional resources are not only the potential impacts on land degradation and crop yield but essentially on controlling the evolution of this quality. Indeed, conventional water with low quality (Dhaouadi et al. 2021) and unconventional resources reused for agricultural require different treatment to reduce the risks on the environment and human health. However, the hydrodynamic behavior of the groundwater and influence of different factors governing chemical and isotopic composition give high degree of uncertainty to efficient management plans. Thus, to ensure effective development strategies the water resources should be in control and stable.

In this context, the present study evaluates the status of groundwater resources and the potential recycled drainage water to secure sustainable development for agro-based regions of Southern Tunisia. Statistical, geochemical and hydro geological approaches have been used to (1) monitor the quality of the used resources, (2) determine the variation amount of the quality of these resources (state of control) and (3) evaluate capability process of these resources to provide resources satisfying common thresholds for agricultural uses.

II. Methodology

II.1. Site description

The studied site is located in SW Tunisia characterized by harsh arid climate and perennial water unbalance is 100 mm/yr. it is characterized by large expansion of agro-system oases covering by 63254 ha for a production exceeding 288700 tons/yr. Agricultural water requirements are supplied exclusively by the deep semi-confined and confined groundwater resources which embody low renewable waters. The increasing frequency of severe shortage periods (long dry seasons) coupled with expansion of new oasis, climate variability and increasing demands and decreasing available water resources, require a supplementary alternative of nontraditional resources namely drainage runoff. The reuse of these resources generally lost to evaporation becomes a persistent need for a region that the overexploitation of groundwater resources reached and exceeded 270% (Besser et al. 2019, 2021; Dhaouadi et al. 2020; Dhaouadi et al. 2021).

The potential use of these important resources requires an evaluation of their permanent use hot only in terms of the released quantity but especially in term of quality suitability for agricultural uses and its evolution during time and across the study area. The dynamic behavior quality represents a main constraint for conventional resources as well.

II.2. Sampling

Sampling campaigns have occurred during June, July 2020 to collect ten samples from water wells used principally for irrigation. A monitoring program for drainage water has been, furthermore, implemented including twelve measuring locations across the different agricultural oasis covered the whole drainage system of the study area. The sampled monitoring locations were chosen depending on the noticeable changes in both water quality and flow debit from the main drains and effluent before pumping station.

To evaluate water chemical composition, the collected samples were analyzed in Soil &Water laboratory of Arid regions Institute.

II.3. Data interpretation

The potential use of the investigated resources is evaluated by quality control model for determining the amount of data variation for water wells and drainage runoff (Fig. 1). In fact, water chemical composition cannot be considered individually as a sufficient decisive factor. The reuse process however must highlight if the continuous use of water may violate upper threshold limits and to ensure variation of water quality with expected predictable or normal levels (Shaban 2014).

→ *Statistical analysis:* the obtained data from field investigation and (or) laboratory analysis were evaluated using principal component analysis (PCA), factor analysis (FA) and hierarchical cluster analysis (HCA) using SPSS 17.1 software.

→ *Control chart*: this graphical classification tool based on statistical process of controlling variability (Montgomery 2004; Carvalhi et al. 2016; Da Conceiçao et al. 2018). These charts, generally, used for industrial process are evaluated according to Montgomery (2004) and Shaban (2014) as important monitoring techniques with high effectiveness in most diverse areas of Knowledge. Different works have applied these statistical approaches in environmental studies namely water quality evaluation (Reis et al. 2011), drainage and waste water performance (Shaban 2014; Orsatto et al. 2015), irrigation system evaluation (Frigo et al. 2016) and pollution (Da Conceiçao et al. 2018).

The control chart based on hypothesis of spatio-temporal evolution of the collected data to evaluate if the process is in a state of statistical control. It is represented by a plot given the upper and lower control limits defining two intervals; not rejecting the statistical control hypothesis and out of bounds for unexpectable or assignable causes (Montgomery 2004; Reid and Sanders 2007; Carvalhi et al. 2016; Da Conceiçao et al. 2018). The used individual chart is defined by three principal limits (Eqs. 1, 2, 3)

$CL = \mu$ (**eq.1**)

$UCL = \mu + 3AM/d_2$ (**eq. 2**)

$LCL = \mu - 3AM/d_2$ (**eq. 3**)

where: CL: medium line;

μ: Medium of observations;

UCL: Upper Control Limit;

LCL: Lower Control Limit

AM: Amplitude of the sample

d_2: Factor for construction

In this case, the upper and lower control limits on the control chart are set ± 3 standard deviation from the mean (Shewhart 1931; Jolliffe 2002; Montgomery 2004; Bersimis et al. 2005).

Process capability and process performance: besides to the stable variation overtime defined as a process in control, the safe use of a process should be followed by quality examination according to a number of thresholds limits outside of technical operation (Oakland 2003). Thus, the quality chart is coupled by process capability defining the inherent ability to produce resources satisfying prior specific conditions (Abu Zahid and Sultana 2008). Capability process index is a numerical summary process that compares the behavior of a product or process to engineering specification. Process capability is the measurements of the capability of the process performed when there are some noise factors and uncontrolled process inputs impacting the process due to which the output of the process could not be in target line and might get deviated from the target .

To examine a process as capable to verify that the stability will yield satisfactory results from the level of quality that should be centered to the specific target and the defined according to specific limits, process capability index help in this verification and if process instability is perceived then the behavior of the process capacity will be unstable not requiring its investigation (Giron et al. 2013). The calculated indices are calculated as the following equations (eqs. 4, 5, 6 and 7)

$Cp = USL-LSL/(3\partial)$ (**eq. 4**)

$Cpk = \min \{USL-\mu / (3\partial) ; \mu-LSL /(3\partial)\}$ (**eq. 5**)

$Pp = USL-LSL/(6\partial)$ (**eq. 6**)

$Ppk = \min \{USL-\mu / (6\partial) ; \mu-LSL /(6\partial)\}$ (**eq. 7**)

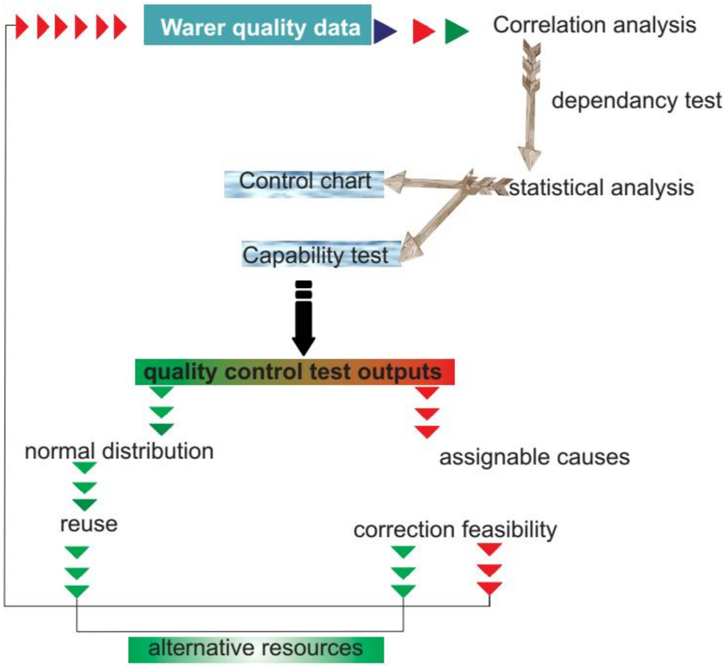

Figure 1: Methodology flowchart

III. Results and discussion

III.1. Water composition

The physic-chemical of the analyzed waters from irrigation wells and from drainage runoff are presented by Table1 both types of water fall into high saline waters to be used for irrigation and generally unadvised for use unless consulted with specialists for more detailed and specific requirements to be applied during irrigation (Tanji and Kielen 2002). The classification of drainage water quality according to the diagram SAR vs. EC (Tanji and Kielen 2002) indicates that all the sampled waters fall into the classification with no reduction in infiltration rate.

Both types of water are classified with high risks of land degradation according to USSL (1954), Riverside (1954), Wilcox (1955) and FAO (2007) thresholds. The calculated ionic ratios display important spatial variation across the study area and fall almost in unsuitable resources for irrigation purposes (Figs. 2 and 3). The obtained data confirm that both resources require accurate examination for their potential impacts on soil fertility. In fact, according to figure 2, a wide variability of drainage water characteristics across the study area without any significant correlation between the salt content and the calculated SAR ratio revealing the influence of farming practices mainly the applied leaching fraction and the used fertilizer amount (Fig. Ec vs. LR,) The classification of the collected drainage water according to the classification of Abu-Zeid and Sultana (2008) indicates that the samples fall into relatively medium to highly saline inducing important risks for the local environment on which they are were released.

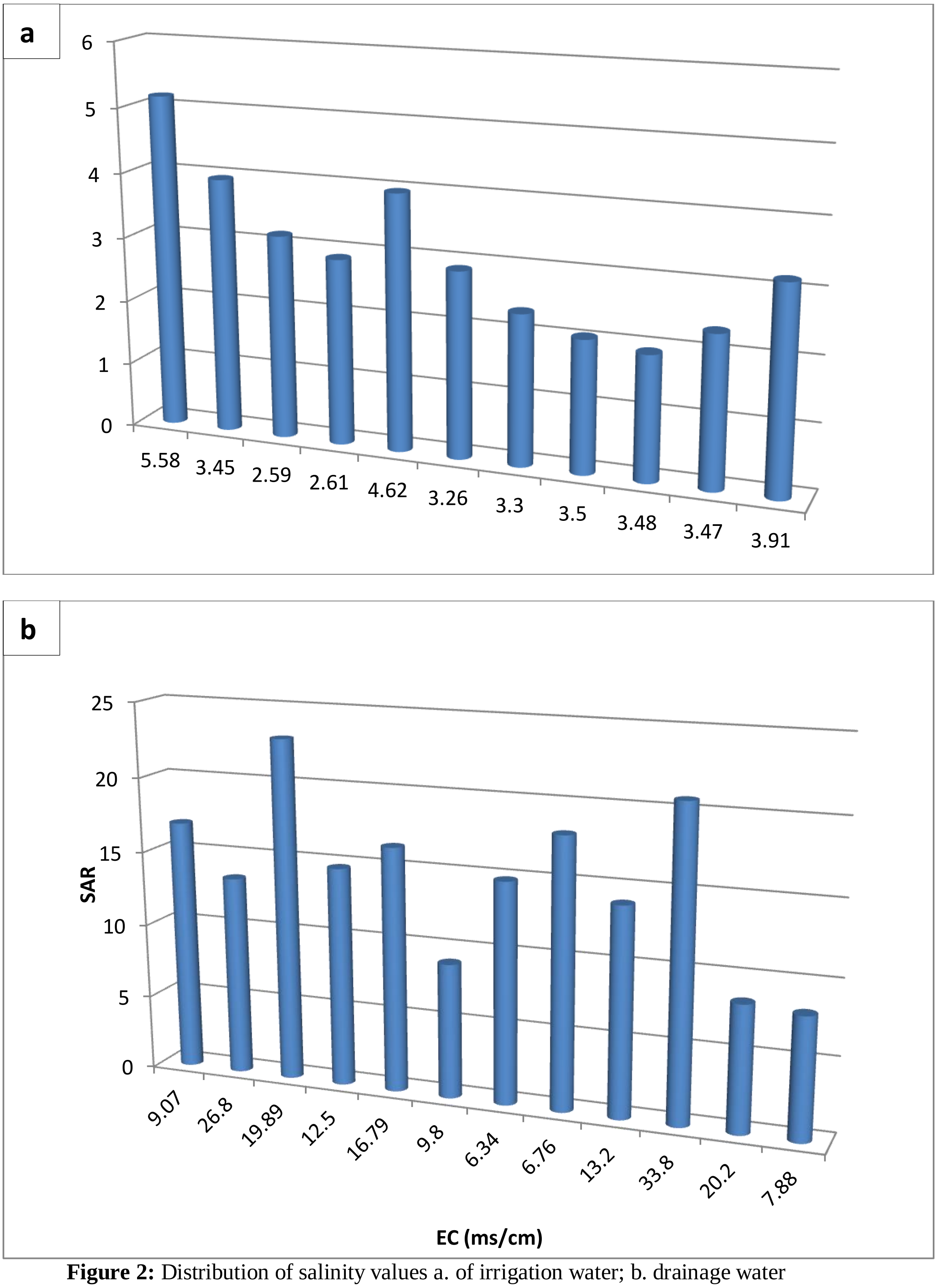

Figure 2: Distribution of salinity values a. of irrigation water; b. drainage water

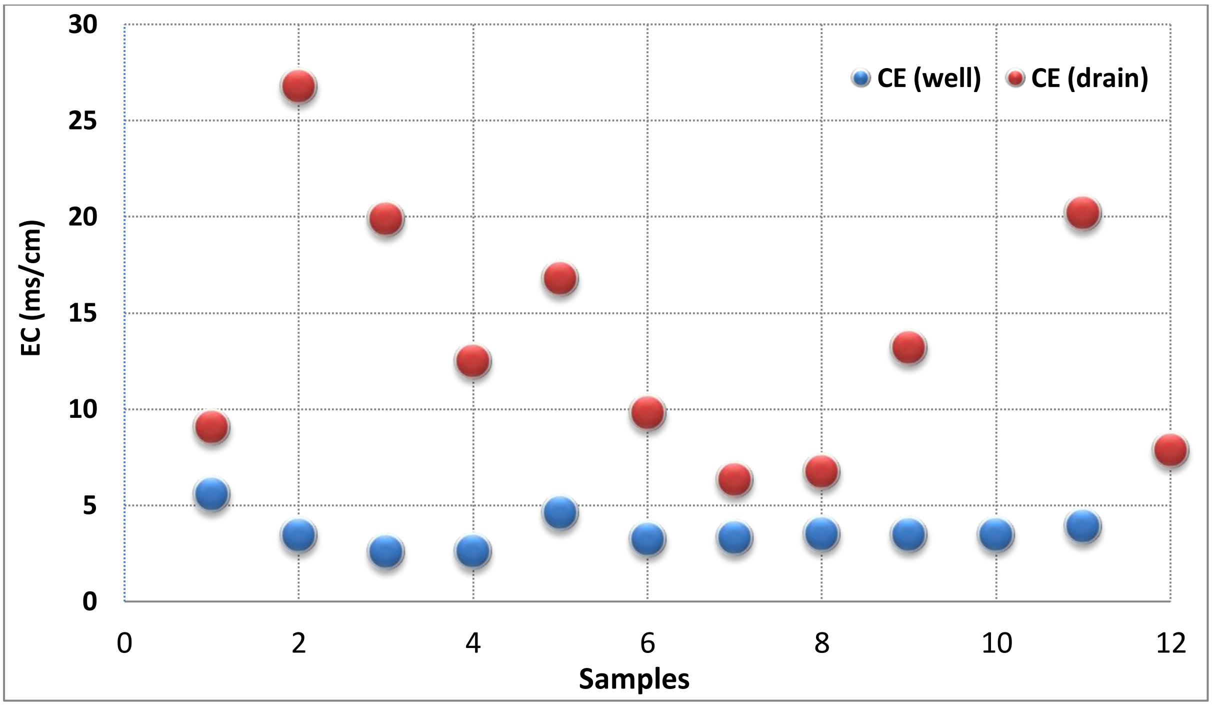

Figure 3: Correlation of EC water and EC drainage

III.2. Quality chart

The investigated parameters show high levels of correlation coefficients indicating important value of significance. All parameters correlate reasonably with the three principal factors extracted from ACP analysis that account more than 98% and 85 % respecti vely for chemical composition and the calculated quality indices. These elements have positive loading for most of the chemical elements and ionic ratios while some parameters illustrate strong negative coefficient explaining multisource of water quality influence pollution (table 1). The statistical analysis highlights important causality links between the parameters Kaiser-Meyer-Olkin measure of sampling adequacy of (0.67) indicate that the sample size is large efficiency to extract principal factors confirmed by Bartlett's test of sphericity X^2 = 189.17

The internal structure of the data evaluated using PCA and HCA analysis indicated that the chemical composition of the collected water wells is influenced by three principal factors that account about account more than 72 and 88 % of total variability of the data relative to the sampled drainage water for chemical composition and quality ionic ratios illustrated by figure 4 and table 1. The distribution of the obtained correlation factors indicates that the first principal parameter seems to be the initial quality of irrigation water while the influence of individual farming practices and the variability of fertilizer application and the different farmer-scale behavior are likely explained by the second and the third factors. The distribution considers as well the indigenous knowledge of local farmers.

The factor scores of the previous three principal factors extracted by PCA to provide quality control chart defined to compare the variability of the output of a process across the study area against upper and lower limits to evaluate if the output fit within the expected specific predictable and normal levels (Reid and Sanders 2007). The illustration given by figures 4 and 5 indicate that all the samples fall within normal distribution. No samples have found outside the set range representing by upper-lower center line. It is concluded that the process of drainage in the study area is in control. Looking at these figures, the observation of water wells and drainage runoff indicate that no samples was outside the set range indicating no assignable causes of variation. These findings prove that the reuse process of drainage water in control with respect to the different investigated parameters

Table 1: distribution of statistical output

data		factors	% of variance	Cumulative %
Water Wells	Geochemical data	1	75.644	75.644
		2	15.652	91.296
		3	6.760	98.057

	Quality indices	1	47.724	47.72
		2	21.461	69.18
		3	15.961	
Drainage water	**Geochemical data**	1	33.62	33.62
		2	19.88	53.50
		3	19.007	72.51
	Quality indices	1	49.06	49.06
		2	23.13	72.20
		3	16.56	88.76

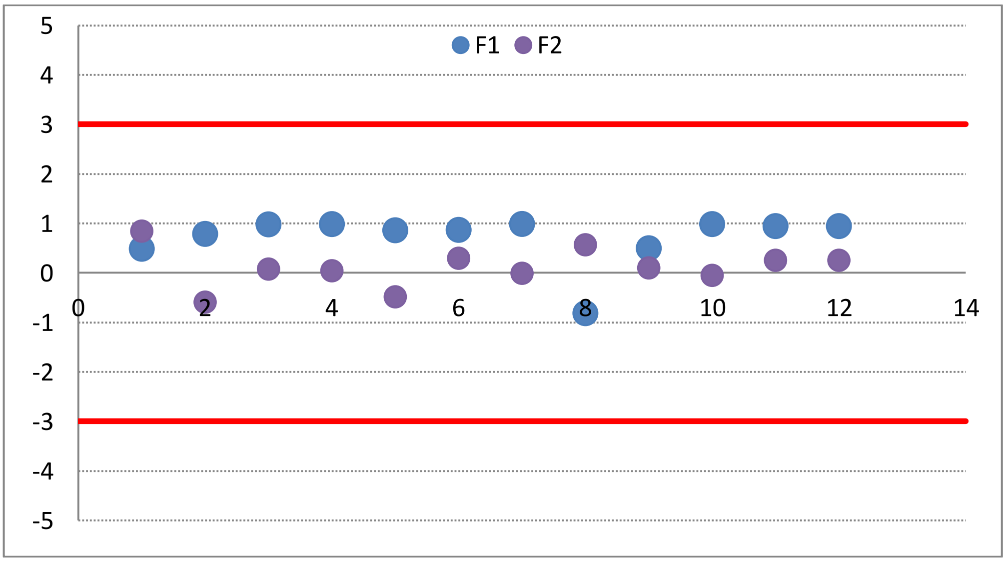

Figure 4: Quality chart of irrigation water wells a. chemical composition; b. quality indices

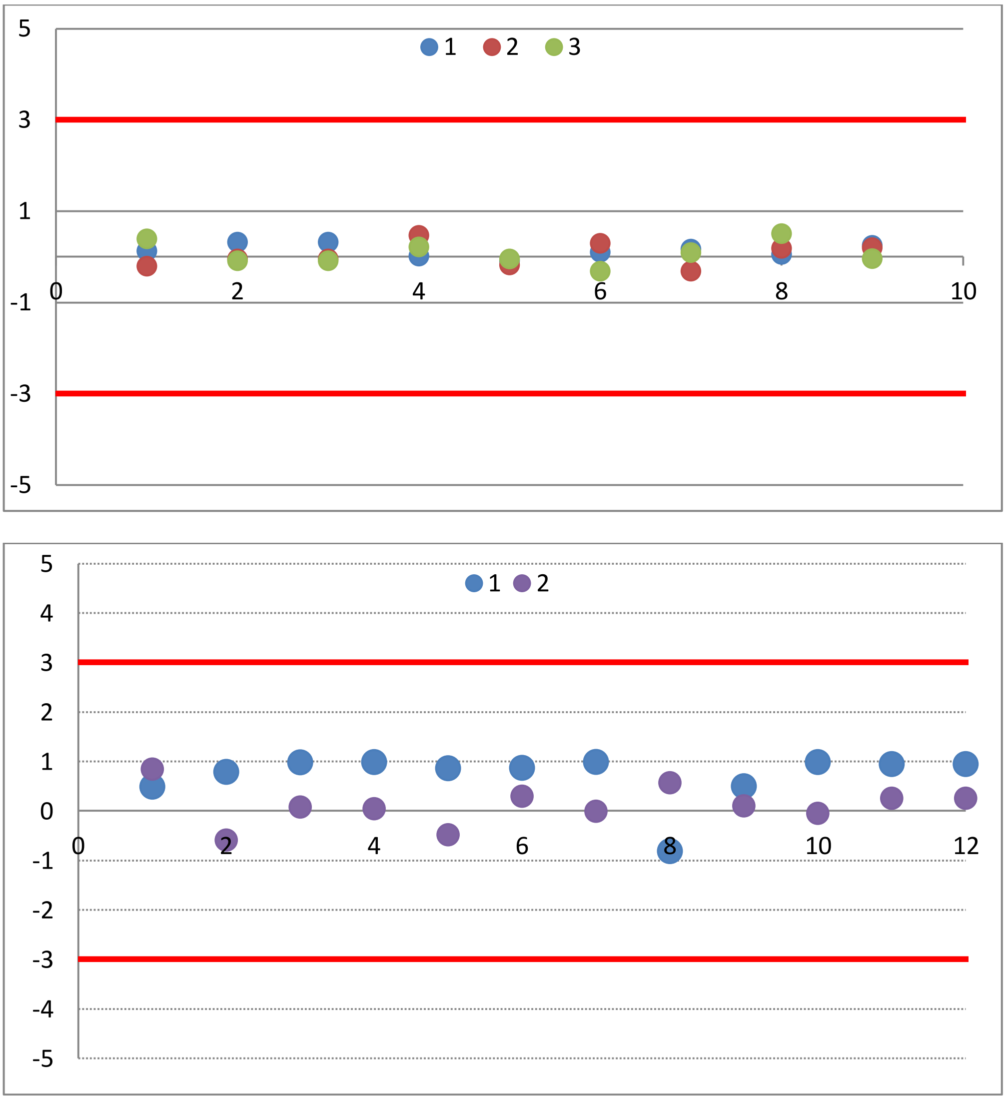

Figure 5: Quality chart of drainage water a. chemical composition; b. quality indices

III.3. Capability and performance indices

To produce an irrigation water with acceptable quality, the use process of water wells and drainage runoff should be in control and capable. Process capability decreases when the probability of having samples outside the specification limits increase (Reid and Sanders 2007; Shaban 2014). Cpk and Ppk consider the centering and check the data with target while Pp and Cp provide information about data spread independently of the a specific threshold values For the current study almost of the data points are crossing the specification limits given by the international thresholds indicating that the process is not capable enough to provide the recommended quality threshold (table 2)

Table 2: distribution of capability and performance indices

Indices	EC	RSC	KR	SSP	RSBC	MH	PI	TH	%Na	SAR	ESP
Cp	1.25	0,041	4,024	4,099	0,042	9,341	3,282	3,619	4,185	2,735	1.83
Cpk	0,907	-1,757	-2,843	-2,628	-1,792	-8,299	-3,389	-1,503	-2,461	-1,332	-1.25
Pp	5.6	0,02	2,012	2,05	0,021	4,671	1,641	1,809	2,093	1,368	0.98
Ppk	0,453	-0,879	-1,422	-1,314	-0,896	-4,15	-1,695	-0,752	-1,23	-0,666	-0.87
Cpm	0,206	0,004	0,234	0,258	0,004	0,187	0,161	0,392	0,281	0,332	0,176

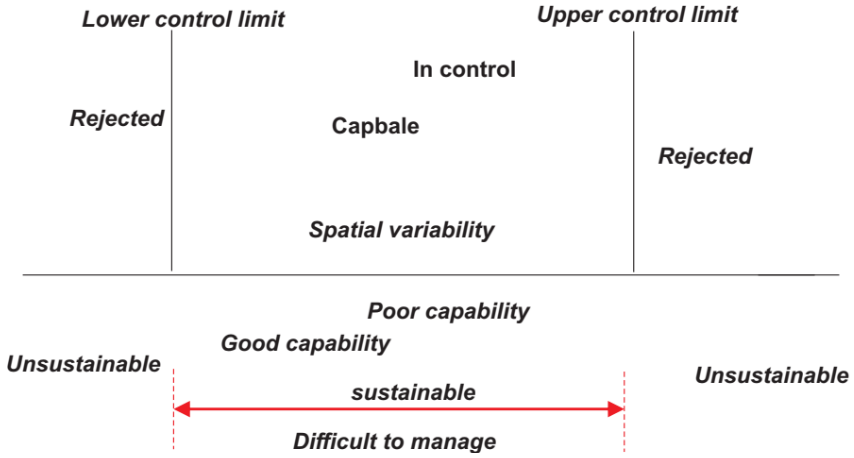

Figure 6: Capability index evaluation

The analyzed waters show according to the figure 7 variable distribution with similar trend for long term use. Water from irrigation wells, however, has a wider spread than expected especially for drainage waters which reflect the poor capability of the sampled waters to satisfy the requirements. Moreover, the narrower variation of the collected runoff waters show a good capability to be managed for short-term performance while the totality of quality indices indicates that the used waters are not capable to satisfy the requirements for permanent use which raises the question here about firstly the efficiency of management plans to optimize the use of freshwater resources and secondly about the sustainability of agricultural production without sustainable resources unfit for irrigation resources (conventional and non conventional)

The difference in the distribution of Cp and Cpk may be explained the spatial variability of the obtained results. Indeed, the quality of the collected waters show variable classification across the study area indicating the influence of different factors namely irrigation technique, groundwater degradation, climate dryness….Given the Cp indicates data spread and width of data range while Cpk reflect the near mean data for short term performance similarly for Pp and Ppk the assessment of the capability process according to these terms highlights important variability indicating that the quality of the used waters is suitable for uses locally but for the quail-totality of the area and (or) for long term performance high risks are expected for agricultural productivity. The statistical approach confirms that the used waters and the potential resources to overcome water shortage are not capable for short and long term performance.

Considering these indices as a summary of a large data and complex information in one single number to establish priorities for improvement activities , The implementation of the efficient required management actions of these resources give the target with some specification limits (threshold) upper and lower control limits defined as the boundaries of the suitability limits that guarantee a fruitful plans of development within large range of variability. The reuse process should be in control to conform the requirements. In the cases where the classification shifts to out of control, managers should identify the local variability and make the required corrective action before the process may take place. This quality control test is essential ensure a reuse process for a sustained period of time.

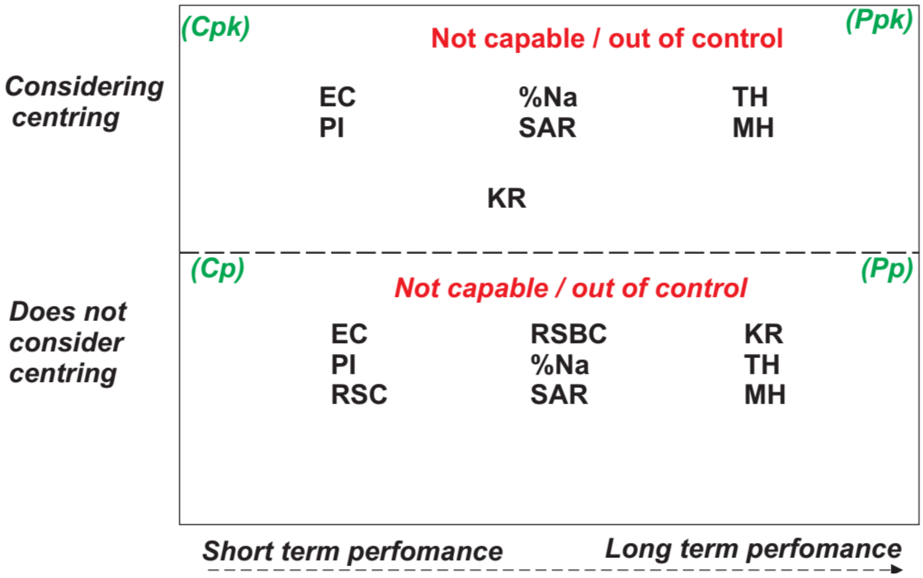

Figure 7: Distribution of the performance indices of the studied samples

IV. Conclusions

The recycled drainage water use for irrigation is generally considered as disruption to the conventional, mal operation, and the adequate or effective performance process is agriculture and especially irrigation. Thus, its use as supplementary alternative for irrigation during shortage periods has defined challenging for social and economic sectors and it is often elusive in practices.

This study indicates, however, using quality model and statistical process control that both these risks and challenges of management and (or) potential risks for the environmental and for human health are not related only to the recycled drainage water but they are more pronounced for the currently used water for irrigation. As according to the obtained data these resources are often in control but not capable to produce safe requirements for short and long performance. The control charts although it displays stable state of control for drainage runoff and irrigation well water illustrates important spatial variability and it confirm coupled with the calculated indices that the management of these resources to sustain permanent productivity is difficult and the dynamic behavior of water quality is unpredictable raining the concern about the potential effects.

The used statistical approach is helpful to highlight the potential management challenges for the process considering their dynamic behavior. This model starts with preliminary field investigation and laboratory analyses and should be completed by engineering action and technical operation to overcome shortage issues and to optimize natural resources exploitation. The results are encouraging for both water types. Indeed, in control resources that is not capable to produce the requirements within the threshold limits may be revalorized by improving drainage, farming practices, pre-treatment, changing cropping patterns. As the response of the solicited resources is in control, the recommended responses to achieve the required permissible limits are multiple, feasible and manageable.

References

[1]. Abu Zahid, Md.; Sultana A. (2008). Assessment and comparison of multivariate process capability indices in ceramic industry, Journal of Mechanical Engineering, vol. ME39, No. 1, June 2008

[2]. Bersimis, S., Panaretos, J; Psarakis, S. (2005). Multivariate statistical process control charts and the problem of interpretation: a short overview and some applications in industry, Proceedings of the 7th Hellenic European Conference on Computer Mathematics and its Applications, Athens Greece

[3]. Besser, H., Dhaouadi L., Hadji, R., Hamed, Y., Jemmali H., 2021. Ecologic and economic perspectives for sustainable irrigated agriculture under arid climate conditions: An analysis based on environmental indicators for southern Tunisia. Journal of Africain Earth Sciences. https://doi.org/10.1016/j.jafrearsci.2021.104134

[4]. Besser, H., Hamed, Y., 2019. Causes and risk evaluation of oil and brine contamination in the Lower Cretaceous Continental Intercalaire aquifer in the Kebili region of southern Tunisia using chemical fingerprinting techniques. Environ. Pol. 253, 412–423.

[5]. Besser, H., Mokadem, N., Redhouania, B., Hadji, R., Hamad, O., Hamed, Y., 2018. Goundwater mixing and geochemical assessment of low enthalpy resources in the geothermal field of Southwestern Tunisia. Euro-Mediterranean J. Environ. Integr. https://doi.org/10.1007/s41207-018-0055-z.

Besser, H., Mokadem, N., Redhouania, B., Rhimi, N., Khelifi, F., Ayadi, Y., Omar, Z., Bouajila, A., Hamed, Y., 2017. GIS based model evaluation of groundwater quality and estimation of soil salinization and land degradation risks in arid Mediterranean site (SW Tunisia). Arab J. Geosc. https://doi.org/10.1007/s12517-017-3148-0.

[6]. Besser, H., Redhouania, B., Bedoui, S., Ayadi, Y., Khelifi, F., Hamed, Y., 2019. Geochemical, isotopic and statistical monitoring of groundwater quality: assessment of the potential environmental impacts of the highly polluted CI water in Southwestern Tunisia. J. Afr. Earth Sci. 153, 144–155.

[7]. Carvalho KQ, Lima SB, Passig FH, Gusmão LK, Souza C, Kreutz C, Belini AD, Arates EJ (2015) Influence of urban área on the water quality of the Campo River basin, Paraná State, Brasil. Brazilian Journal Biology 75(4):96- 106. DOI: http://dx.doi.org/10.1590/1519- 6984.00413suppl

[8]. Da Conceição, K Z., Boas, M A. Vilas, S, Silvio C., Remor, M B.,; Bonaparte, D I.. (2018). Statistical control of the process applied to the monitoring of the water quality index. Engenharia Agrícola, 38(6), 951-960. https://dx.doi.org/10.1590/1809-4430-eng.agric.v38n6p951-960/2018

[9]. Dhaouadi, L., Besser, H., Wassar, F., Karbout, N., Ben Brahim, N., Wahba, M., Kang, Y. (2020) Agriculture sustainability in arid lands of southern Tunisia: Ecological impacts of irrigation water quality and human practices. Irrigation and Drainage journal. https://doi.org/10.1002/ird.2492

[10]. FAO (2007) FAOSTAT, FAO Statistical Databases. http://faostat.fao.org/.

[11]. Frigo JP, Vilas Boas MA, Frigo JP, Frigo EP (2016) Comparação entre gráficos de controle de Shewhart, CUSUM e MMEP no processo de irrigação por aspersão convencional. Irriga 1(1):56-70. DOI:http://dx.doi.org/10.15809/irriga.2016v1n01p56-70

[12]. Gautam, Y, Andersen, P (2016) Rural livelihood diversification and household well-being: insights from Humla, Nepal. J. Rural Stud. 44, 239–249. https://doi.org/ 10.1016/j.jrurstud.2016.02.001

[13]. Giron E, Opazo MAU, Rocha Júnior WF, Gimenes RMT (2013) Aplicação do controle estatístico de processo emuma empresa do setor avícola. Revista de administração einovação 10(4):38-62. DOI: http://dx.doi.org/10.5773/rai.v10i4.891

[14]. Jolliffe, I.T. (2002). Principal component analysis, second edition, 2002, 1986 Springer-Verlag New York

[15]. Montgomery CD (2004) Introdução ao controle estatístico do processo. Rio de Janeiro, LTC, 4 ed.

[16]. Oakland, J.S. (2003). Statistical process control, fifth edition. First published 1986 Reid, D.R. & Sanders, N.R. (2007). Operations management: an integrated approach. John Wiley, 3rd Edition, 671 pages.

[17]. Orsatto F, Vilas Boas M, Eyng E (2015) Gráfico de controle da média móvel exponencialmente ponderada: aplicação na operação e monitoramento de uma estação de tratamento do esgoto. Engenharia Sanitária e Ambiental 20(4):543-550. DOI:http://dx.doi.org/10.1590/S1413- 1522015020040093742

[18]. Reid, D.R. ; Sanders, N.R. (2007). Operations management: a integrated approach. John Wiley, 3rd Edition, 671 pages

[19]. Reis CF, Vilas Boas MA, Hermes E, Reisdorfer M (2011) Avaliação da qualidade da água para irrigação em Salto do Lontra – PR. Engenharia Ambiental: Pesquisa e Tecnologia 8(1):69-78

[20]. Richards, L.A., (1954) Diagnosis and Improvement of Saline and Alkali Soils. USDA Hand book, p. 160, 60

[21]. Shaban, M. (2014). Drainage Water Reuse: State of Control and Process Capability Evaluation. Water, Air, & Soil Pollution. 225. 1573-2932. 10.1007/s11270-014-2168-6.

[22]. Shewhart, W.A. (1931). Economic control of quality of manufactured product. New York: Van Nostrand, 1931. Reprinted by American Society for Quality, Milwaukee, 1980

[23]. Tanji K K ; Kielen N C. (2002) agricultural drainage water management in arid and semi-arid areas. FAO irrigation and drainage paper; food and agriculture organization of the united nations. ISBN 92-5-104839-8

[24]. U.S.S.L, (1954) Diagnosis and improvement of saline and alkaline soils. U.S. Dept. Agricult. HandB. 60, 160.

[25]. Wilcox, L.V., (1955) Classification and Use of Irrigation Water, vol. 969. US Geological Department Agri. Circ, p. 19

Nawel Meftahi, et. al. " Understanding the multivariate process controlling the long term use of the conventional and unconventional resources in the Tunisian Oasis agro-systems." *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 16(02), (2022): pp 12-22.