Developing new approaches and strategies to promote sustainability and environmental integration in the Mediterranean region

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Today, the Mediterranean region faces environmental degradation that is accelerating at an unprecedented rate (Ksibi et al. 2021a). The main causes are climate change, increasing pollution, urban growth, and the overexploitation and unsustainable use of resources due to rapid population growth. The effects are seen in several indicators such as the warming, more frequent extreme events, severe droughts, water shortages, contraction of natural resources, changes in land use and landscape deterioration, decreasing agricultural yields, biodiversity loss, deterioration of the ecosystems, corrosion of the natural coastal environment, sea-level rise, and ocean acidification. In addition to these more recent issues, the Mediterranean region naturally experiences a number of hazards such as floods, droughts, desertification, fires, catastrophic forest diebacks, earthquakes, and volcanic eruptions.

In view of this disquieting situation, the most vital sectors, namely “water, food, energy, health and security” are seriously under threat, putting the quality of human life and the well-

being of this region at risk (Fig. 1). This is particularly troubling in light of the current studies and future scenarios which consistently point to the emergence of significant and increasing risks in the coming decades (e.g., the risk of desertification) (Fig. 2). Consequently, policies for the sustainable development of the Mediterranean region and its surroundings need to mitigate these risks and create innovative adaptation strategies.

In this context, there is an urgent need to reinforce the process of environmental integration which consists of ensuring that decision-makers from related sectors incorporate environmental considerations into their various activities. Moreover, knowledge exchange and collaboration between the countries of the northern and southern shores of the Mediterranean on emerging environmental issues should be promoted and fostered. This will alleviate the problem of inadequate information of the more vulnerable southern Mediterranean countries, where few systematic observations schemes and impact models are based.

In sum, in order to create policies for the sustainable development of the Mediterranean region as a whole, to mitigate the considerable environmental risks and to develop adaptation options, it is essential to foster North/South Mediterranean collaboration, not only to streamline the policies and adaptation strategies but also to share existing environmental scientific knowledge across disciplines to provide a better understanding of the overall and shared risks posed.

In this context, to minimize the disparities between northern and southern Mediterranean countries, to fill the knowledge gap, and also to improve the performance of southern Mediterranean countries on various environmental indicators, the Euro-Mediterranean Conference for Environmental Integration (EMCEI-2019) took place for the second time after EMCEI-2017 in Sousse, Tunisia (Fig. 2). Its main focus was to advance innovative approaches that contribute to achieving a sustainable environment in the Mediterranean and surrounding regions and to establish a continuous scientific forum to promote the exchange of knowledge and

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Fig. 1 The FAO approach to the Water-Energy-Food Nexus (FAO, 2014)

collaboration between the countries of the northern and southern shores of the Mediterranean on emerging environmental issues.

After the success of the first EMCEI (www.emcei.net/ 2017) which was launched in 2017 to endorse and promote the *Euro-Mediterranean Journal for Environmental Integration* (Ben Dhia et al. 2016; Cramer 2017; Kallel et al. 2018, 2020), the second installment in 2019 (www.emcei.net/ 2019) tackled emerging environmental issues together with new challenges, i.e., with a focus on innovative approaches that can create a sustainable environment in the Mediterranean

and surrounding regions and by supporting decision-makers from related sectors in integrating environmental considerations into their various activities.

Over 300 participants from 36 countries and 12 panelists, from both the northern and southern shores of the Mediterranean, gathered in Sousse for the conference on partnerships organized by the Editorial Office of the *Euro-Mediterranean Journal for Environmental Integration* in collaboration with Springer. The EMCEI-2019 conference aimed to provide a forum that facilitated a better exchange of knowledge between scientists and policymakers so that the

Fig. 2 The vulnerability of the Mediterranean region to desertification

Environmental Integration process could be improved and streamlined (Fig. 3).

All the papers presented during the conference as oral and poster sessions, keynote lectures, and during the workshops were compiled in a volume of conference proceedings entitled “Recent Advances in Environmental Science from the Euro-

Mediterranean and Surrounding Regions” (2nd Edition), subtitled “Proceedings of Euro-Mediterranean Conference for Environmental Integration, Tunisia (2019)” and which includes 357 chapters (short conference papers) published by Springer and successfully indexed in the Scopus database (Ksibi et al. 2021b). Chapters (available from DOI: 10.1007/

Fig. 3 A panel discussion during the 2nd EMCEI, Tunisia 2019

978-3-030-51210-1) are categorized into 13 broad sections to reflect the main topics addressed at the conference, namely:

1. Engineering applications for environmental management;
2. Process control, simulations, and intensification for environmental management;
3. Ecotoxicology, environmental safety, and bioremediation;
4. Biotechnology for environmental management;
5. Climate change-related effects on the environment and ecological systems;
6. Natural resources, agriculture, and the environment;
7. Smart technologies for environmentally friendly energy production;
8. Remote sensing and GIS for environmental monitoring and management;
9. Environmental impacts of natural hazards and environmental risk assessment;
10. Sustainable management of marine and coastal environments;
11. Sustainable management of the urban environment;
12. Sustainable management of the indoor and built environment;
13. Environmental-change-related impacts on human health.

This special issue (SI) of the Springer Journal Environmental Science and Pollution Research (ESPR) entitled “Selected Case Studies on the Environment of the Mediterranean and Surrounding Regions” is a collection of the best papers presented at the 2nd EMCEI (2019).

It consists of 31 papers on various aspects of the earth and environmental sciences, including eight papers focused on the conference topic “Engineering Applications for Environmental Management”:

1. Guiza et al. (2020) prepared for the first time keratin/cellulose (CF/C) cryogels using chicken feathers (CF) and cardboard (C) for oil/solvent elimination. The synthesized CF/C cryogel showed an interesting absorption capacity (6.9–17.7 times the initial cryogel weight) compared with other biosorbents, a fast absorption rate for various oils and organic liquids, and excellent recyclability and reusability. In this study, the cryogels were reused by simple absorption/distillation and absorption/desorption processes.
2. In another study conducted by Karoui et al. (2020), Tunisian reed-based-beads (BBR) were prepared and characterized, and their efficiency for the simultaneous removal of oxytetracycline (OTC) and cadmium (Cd (II)) was evaluated and then optimized using central composite design under response surface methodology. In this work, the modeling of isotherms revealed that the Freundlich/Jovanovich model and Brouers-Sotolongo

equation satisfactorily described the sorption process of OTC and Cd (II), respectively.

3. The Othmani et al. (2020) study was devoted to the synthesis of hybrid materials based on Tunisian *Luffa cylindrica* and 4% of Zn^{2+} by the precipitation method with and without alternating current for the phenol removal from water. This study confirmed the enhancement of the phenol adsorption by hybrid materials compared with raw *Luffa cylindrica*.
4. Maaloul et al. (2020) focused on the simple preparation of two novel biosorbent beads: BASB/STMP and CNFB/STMP, derived respectively from bleached almond shell (BAS) and cellulose nanofiber (CNF) from almond shell by means of chemical cross-linking with sodium trimetaphosphate (STMP). The isotherm models were successfully fitted to the Redlich-Peterson and Sips model for BASB/STMP and CNFB/STMP, respectively. Moreover, this study showed that the BASB/STMP sample has an excellent performance in terms of regeneration and reuse compared with the CNFB/STMP bead.
5. The process of adsorption from water solutions containing a ternary system of Cu (II), Zn (II), and Ni (II) ions onto buckwheat hulls as an adsorbent was presented by Tomczak and Kaminski (2020). This study confirmed the fact that the ability of buckwheat hulls to remove heavy metal ions is in the following order: Cu (II) >> Ni (II) > Zn (II).
6. Castelvetro et al. (2021) provided an important insight into newly developed analytical protocols for the detection, identification, and quantification of microplastics (MPs). In their work, they also discussed case studies on most commonly found MPs polymers and their environmental degradation by-products in marine and freshwater sediments.
7. In the same context, Chouchene et al. (2020) investigated the types, occurrence, and distribution of MPs in sediments from southwest of Kerkennah archipelago, Tunisia, and they reported an extensive distribution with an average abundance of MPs up to 611 items/m². Their study revealed a clear tendency of trace elements (Zn, Cu, Pb, Cr, and Ni) increase in sediments with higher abundance of MPs.
8. Selmi et al. (2020) investigated the use of *Agave americana* fibers (AGF) as a precursor for activated carbon (AC) preparation via chemical activation using phosphoric acid (H₃PO₄). The influence of the preparation conditions on the adsorption capacity of the prepared AC toward Alpacide Yellow (AY) was studied. The prepared AC showed a higher adsorption capacity toward AY (5.71 mg/g) as compared with that of the commercial activated carbon (5.27 mg/g).

Four papers focused on the conference topic “Biotechnology for Environmental Management”:

1. Chaher et al. (2020) investigated the potential of windrow food and green waste composting in Tunisia. In this study, the state of maturity and stability of the generated compost was identified by determining several indicators including moisture, organic matter, C:N ratio, pH, and the macro and micro-nutrient concentrations. Experimental research findings showed that the finished compost demonstrated acceptable physiochemical properties (MC, TOC, TKN, total P, total K, heavy metals).
 2. Ibrahim et al. (2020) studied the inactivation of hepatitis A in wastewater by 254-nm ultraviolet-C irradiation. This study confirmed that the hepatitis A seasonal distribution varies by geographic location. Besides, the treatment applied to sewage samples via UV irradiation proved to be efficient against bacteriological parameters especially the fecal indicator bacteria.
 3. In another work, Bhattacharya et al. (2020) presented the fermentative production of bacterial nanocellulose (BNC) by using *Komagataeibacter xylinus* strain SGP8 and the characterization of the obtained nanocellulose. The study showed that the adsorptive capacity of BNC could be enhanced with the usage of BNC-CaCO₃ composite. The composite preparation process is simple and eco-friendly and does not involve harmful chemicals.
 4. The assessment of the partial nitrification/anammox process in a single-stage granular sequencing batch reactor for on-site decentralized treatment was presented by Visigalli et al. (2020). The technical feasibility of the process was assessed by treating wastewater from five digital textile printing industries in a laboratory-scale reactor. In this study, a process modeling was applied to experimental data and a good fitting was obtained.
- with cooperation and collective action would be the key options to enhance resilience of rural households and farming systems.
3. In another study, Dineva (2021) performed a survey on water environment in the black sea area on the Bulgarian coast throughout 2015–2018. This study ascertained a relationship to climate showing the sea surface temperature increase in 2015–2018 compared to 1995–2000. Besides, this study showed that the biggest sea surface salinity fluctuations were at 1 mile in front of Cape Galata.
 4. Bouchelouche et al. (2021) studied the impact of heavy metals on benthic macrofauna using multivariate analyses in coastal wetland of Reghaia in Algeria.

This SI also includes 12 papers focused on the conference topic “Natural Resources, Agriculture and the Environment”:

Four papers focused on the conference topic “Climate-Change-Related Effects on the Environment and Ecological Systems”:

1. Rhif et al. (2020) assessed the inter-annual vegetation changes from 2001 to 2017 in northwestern Tunisia through non-stationary Normalized Difference Vegetation Index (NDVI) time series (TS) of MODIS satellite data. The use of the wavelet transform (WT) multi-resolution analysis (MRA-WT), statistical test, and meteorological data helped in improving their trend analysis.
2. Ben Nasr et al. (2021) applied a path structural equation model (SEM) to analyze and predict the climate change resilience of agricultural production systems using the partial least squares method (PLS). Their results showed that rural areas in semi-arid Tunisia are characterized by overall vulnerability and remain threatened against negative impact of climate change. They pointed out that integrated systems, income diversification, along
1. Gold mining reject (GMR) was valorized in the ceramic field, as a substituent of feldspar, as demonstrated by Baziz et al. (2021). In their study, they optimized the incorporation of up to 30% of GMR in ceramic. The mechanical and environmental characterization tests confirmed the reliability and safety for the resulting products (fair strength, elasticity, porosity, and immobilization of heavy metals).
2. Aouiti et al. (2020) focused on the groundwater quality assessment for different uses using various water quality indices in semi-arid region of central Tunisia. This study revealed that the majority of samples in Hajeb Layoun-Jelma basin are not appropriate for irrigation uses.
3. In another paper, Torkashvand et al. (2020) used a combination of the SWARA (Stepwise Weight Assessment Ratio Analysis), entropy, and GA (genetic algorithm) to develop detailed groundwater vulnerability maps.
4. Mahmoudi et al. (2021) identified the suitable sites for artificial recharge with treated wastewater in Ariana City (Tunisia) by applying a combination of GIS-based multi-criteria evaluation techniques, including Boolean logic, fuzzy set theory, analytic hierarchy process pairwise comparison, and weighted linear combination. The evaluation involved fifteen criteria (of geological, environmental, and economic concerns) and led delimit three candidate sites, which were further ranked for suitability by applying the ELECTRE III method.
5. The trophic state of three reservoirs located in the north-west of Algeria based on the physico-chemistry of water, and the community of rotifers was examined by Smaoune et al. (2020).
6. However, the surface quality in the Kebir-Rhumel catchment area (northeast Algeria) using biotic indices and physicochemical analyses was evaluated by Saal et al. (2020). The biotic indices used in this study confirmed

the diagnosis of the physicochemical analysis demonstrating a very degraded quality at Rhumel wadi.

7. Rufino et al. (2020) presented the first detailed low-scale maps realized for the Matese massif chain, southern Italy. In this work, the spatial distribution of the main chemical and isotopic features was investigated by means of TDIC, pCO₂, and $\delta^{13}\text{C}$ -TDIC distribution maps.
8. The sustainable management of a cropping system under salt stress conditions in Korba (a Cap-Bon eastern coastal area in Tunisia) was investigated by Bani et al. (2020).
9. Ghannem et al. (2020) in a study about the effects of regulated deficit irrigation applied at different growth stages of greenhouse grown tomato offered a practical irrigation strategy to farmers, in order to apply water stress at the appropriate tomato growth stages.
10. However, Rafik et al. (2020) indicate in their paper that quinoa has a great potential for both producers and consumers in Morocco and can be a judicious solution toward achieving food and nutritional security.
11. Furthermore, a techno-economic assessment of quinoa production and transformation in Morocco (Rafik et al. 2021) showed that irrigation, organic amendment, and mechanized operations allow to treble quinoa productivity and to cut seed production and processing cost by more than half.
12. Shen (2020) investigated the reliability of using camphor wood (*Cinnamomum camphora*) as museum storage materials. Various tests and analysis on wood samples aged for different years provided abundant and valuable information to understand the mechanism of metallic corrosion caused by camphor wood.

In this SI, there is one paper focused on the evaluation of the effect of physiological conditions and biochemical factors of mussels *Mytilus galloprovincialis* in radioactivity monitoring programs along the Algerian coast (Guendouzi et al. 2020). This study showed that the mussels' bioaccumulation capacity for radionuclides was dependent on the growing site and the biomonitoring time period. In another paper, the effect of environmental factors on zooplankton diversity, abundance, and distribution in the Ghrib Dam (Algeria) water body was investigated (Hamil et al. 2020).

The human health topic was included in this SI through the Taleb et al. (2020) paper focused on the analyses of the associations between body mass index, waist circumference, waist circumference to-height ratio, and hypertension in an Algerian adult population.

We hope this SI will contribute to filling the environmental information gap between the northern Mediterranean countries and the more vulnerable southern Mediterranean countries and other surrounding regions. Certainly, more work is needed and EMCEI mission is still far from complete (Fig. 3).

We are committed to continuing this mission to establish closer ties between the countries of the northern and southern shores of the Mediterranean so that a much closer scientific collaboration can develop new approaches and strategies to promote sustainability and environmental integration in the Mediterranean region.

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Dr. Mohamed Ksibi obtained his MSc (1989) and PhD (1993) degrees in Applied Chemistry from the University of Poitiers, France. Afterwards, he undertook a 1-year post-doctoral research fellowship at the National Institute of Scientific and Technical Research (Tunisia, 1995). In 2003, he obtained his accreditation to supervise research (HDR) in Chemistry from the University of Sfax, Tunisia where he was then appointed Professor of Chemistry (2009). In 2011, he be-

came the Director of the High Institute of Biotechnology in Sfax. His research focuses on chemicals in the environment, water, and wastewater treatment and reuse. He developed new assessment methods for toxicity in water containing various pollutants (dyes, phenolic and pharmaceutical compounds, polluted water from pulp and paper mills, domestic wastewater, etc.) following different wastewater treatment techniques. He has co-published about 60 papers in indexed journals. He has been involved in the establishment of several joint scientific projects with Moroccan, Portuguese, German, and Japanese scientists on the quantification and risk assessment of emerging organic contaminants and heavy metals in soils and surface waters in Tunisia. More recently, he has participated in the NATO-SfP project “Remediation Processes in Uranium and other Mining Explorations.” Prof Ksibi is the co-Editor-in-Chief of the *Euro-Mediterranean Journal for Environmental Integration* (Springer) since 2019.

Dr. Hamed Ben Dhia is currently Professor Emeritus in the Sfax National School of Engineers at the University of Sfax, Tunisia. He received his education in Tunisia and then in France where he graduated with a PhD degree in Geothermal Energy & Aquifers Modeling from the Faculty of Sciences, Bordeaux and Ecole des Mines in Paris. His working career started in Libya in water research for the Saharan region (1973–74); he then moved to Morocco with the

National Phosphate Company (1975–1978), before returning to Tunisia as a lecturer/professor at the University of Sfax (1979–2012), active in several research projects concentrating on hydrogeology, geothermal energy, environmental sciences, and engineering geology. He has co-published more than 180 papers in national and international journals. Furthermore, he has supervised and successfully handled about 50 master and 30 doctoral theses. Prof Ben Dhia was appointed Head of the Earth Science Department (1982–1986) and Director (1993–1997) of the National School of Engineers of Sfax, and President (Rector) of the University of Sfax (1997–2011). This long career has enabled him to acquire skills and expertise in several fields such as natural resources, green growth, university management and entrepreneurship learning/coaching. In 2016, Prof Ben Dhia, along with Dr Khélifi (Springer) and other scientists based at the University of Sfax and some northern Mediterranean shore universities, founded the *Euro-Mediterranean Journal for Environmental Integration* (Springer).

Dr. Nabil Khélifi undertook fellowships at the System for Analysis, Research and Training (START) in 2005 and the German Academic Exchange Service (DAAD), as part of his PhD studies in Marine Geosciences at the University of Kiel in Germany (2006 to 2010). After his PhD, he received a research grant from the German Science Foundation (DFG) to conduct research projects at the GEOMAR Ocean Research Centre in Kiel, Germany, on

oceanography and climate reconstructions in the North Atlantic and the Mediterranean (2010 to 2013). His research findings have been presented at many conferences and published in esteemed journals. He co-organized workshops on the Pliocene climate in Bordeaux, France

(2009) and Bristol, UK (2013), funded by the European Science Foundation (ESF). In late 2013, he received the Swiss Government Excellence Scholarship (SGES). In 2014, he joined Springer in Heidelberg, Germany, as an Editor, and was promoted to Senior Editor in 2017 responsible for developing their publishing program in the MENA region. He is active in educational seminars for authors, reviewers, and editors to help improve publication output and quality. He is a visiting lecturer at King Saud University, KSA, where he gives MSc lectures on scientific presentations and publishing techniques, as well as career development workshops. Dr Khélifi has launched two Springer conferences (more details at www.emcei.net and www.cajg.org). In 2016, he was awarded the Africa Green Future Leadership Award for his promotion of publications from Africa. In 2020, he received the Saudi Society for Geosciences Award for successful management of the *Arabian Journal of Geosciences* (Springer).