Introduction to "Water Resources in Algeria: Water Quality, Treatment, Protection and Development"

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Contents

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Abstract This chapter summarizes the main contents of the chapters presented in the book "Water Resources in Algeria: Water Quality, Treatment, Protection and Development" according to its three themes. Consequently, the latest finding of research on water quality and modelling, wastewater treatment and reuse and protection of water resources. Also, key information on the development and future of water resources in Algeria were highlighted. The editors believe that the contained information are important to support the sustainable development in Algeria as an arid country in the MENA region.

Keywords Algeria, Desalination, Modelling, Sustainable development, Water pollution, Water protection, Water quality, Water reuse, Water treatment

1 Background

"Water is life"; as long as water is available and of good quality, it sustains life on earth including human livelihood. However, the deterioration of water quality by any mean or the disturbance of water biogeochemical cycle, causing changes in water availability and/or quantity, can directly harm human health or severely damage the environment with negative socioeconomic repercussions that affect agriculture, ecosystem integrity and human well-being [1, 2]. Within the frame of sustainable development, it is crucial to maintain water available, sufficient and of good quality. This requires first the understanding of both surface water and groundwater characteristics [3–5] and also implements all the mechanisms and policies to protect and ensure wise uses of water resources including treatment and reuses of wastewater or desalination [3].

Water overuse, misuse and abuse are the main cause of water shortage in many areas. Water pollution is another form of water unavailability resulted from high population growth rate often combined with significant urban sprawl [1, 6]. The management and conservation of water resources represent a real challenge under climate change, desertification and increasing water demand, especially in arid and semiarid regions [7, 8]. Indeed, the aims of current book are to deal with aspects water quality, treatment, protection and development of water resources in Algeria.

The book started with the introduction part which consists of the current chapter, where the main technical elements of each chapter are summarized and presented under its relevant theme. In part I of the book [3] and in its second chapter [9], a summary of the different components of the Water resources in Algeria was presented based on the Scopus database. In this part of the book, the following main themes are covered in 11 chapters:

- Water Quality and Modelling
- Treatment and Protection

– Development and Future of Water Resources

The next sections present briefly the main technical elements of each chapter under its related theme.

2 Chapters' Summary

2.1 Water Quality and Modelling

This theme is covered into three chapters. Chapter 2 is titled "Kalman Filter for Spatio-Temporal Modelling and Prediction of Algerian Water Resources Variability: Case Study of Precipitation and Streamflows at Monthly and Annual Scales". The main target of the chapter is the application of discrete Kalman filter for spatiotemporal modelling and prediction of surface water variability in Algeria. The recursive structure of its algorithm and its ability to integrate the effects of measurement and system noise to produce optimal predictions make its particularity. Also, the chapter focuses on surface water resources in Algeria already negatively impacted by climate change. This impact results in water scarcity affecting all components of the hydrological cycle, particularly rainfall. The spatial and temporal variability of this shortage is an additional complexity that presents a real challenge for water managers. For a better understanding of situations where everything changes over time and space, dynamical spatiotemporal forecasting models are highly recommended. One of the most used dynamic models in stochastic estimation from noisy measurements is the Kalman filter (KF). The discrete KF is a recursive technique for estimating the state of a system in the presence of noise; it describes the recursive solution to the problem of linear filtering of discrete data. This technique provides optimal estimates in the least-squares sense. In addition, it has several advantages. One of these advantages is that stationarity is not a prerequisite. This is interesting because it allows for changes in the model parameters and variances, which is a way that accommodates the non-linear response of hydrologic systems. Another advantage of KF is the recursivity in the time domain which offers the possibility of real-time prediction. But the big advantage of KF is to provide with the prediction error at each update, and this is a manner to measure the quality of the provided estimates accurately.

While Chap. 3 is titled "Predicting Water Quality Indicators from Conventional and Non-Conventional Water Resources in Algeria Country: Adaptive Neuro-Fuzzy Inference Systems Versus. Artificial Neural Networks", the chapter is aiming to achieve (1) modelling chemical oxygen demand (COD) at Wastewater Treatment Plant (WWTP) and (2) dissolved oxygen concentration (DO) at a drinking water treatment plant using two data-driven models: the adaptive neuro-fuzzy inference system (ANFIS) and artificial neural networks (ANN). The use of data-driven models for predicting several water quality parameters at drinking and wastewater treatment plants has gained much popularities, and several applications can be found

in the literature. In the present study, two well-known models, namely, adaptive neuro-fuzzy inference system (ANFIS) and artificial neural networks (ANN), were applied and compared in order to predict two water quality indicators: (1) chemical oxygen demand (COD) at Sidi Marouane Wastewater Treatment Plant (WWTP), east of Algeria, and (2) dissolved oxygen concentration (DO) at the drinking water treatment plant of Boudouaou, Algeria. The two models were calibrated during the training phase and later validated using a validation dataset. By comparing a series of input combinations using several water quality variables, the accuracy of the models was evaluated and compared with the results obtained using the standard multiple linear regression model (MLR). The obtained results indicated that (1) ANFIS model optimized using the subtractive clustering algorithm have achieved more accuracy compared to the ANN and MRL models, (2) the MLR model is not suitable for modelling the DO and COD and the have provided low accuracy during the training and the validations phases.

On the other hand, Chap. 4 is titled "Organic Chemical Characterization of Water of the Northwestern Algerian Dams". The chapter focuses on making (1) an organic chemical characterization of surface water of some dams belonging to two watersheds located in northwestern Algeria and which are generally used for human consumption and for irrigation purposes, (2) to identify the polluted dams and assess spatial and temporal variability of the analysed parameters. This is due to the fact that among the major problems of water quality of dams are the anthropogenic effects (municipal waste discharge, agricultural and industrial activities) as a result of releasing wastewaters through rivers. This could partially be overcome by identifying polluted sources and enforcing the laws governing the conditions for the wastewater discharge into natural watercourses. Maintaining standards of the water quality of dams requires the control of pollutant flows not only at the dams but also at the watershed level, especially with regard to nutrient and metal contents.

Linked to the intensification of human activities on the watershed level (e.g. industry, agriculture, urban discharges), the increase in nutrients brings about an acceleration of the natural process of eutrophication and often a rapid disturbance of ecosystem equilibrium state.

For example, among nutrients, phosphorus is an element whose excess in water is responsible for phytoplankton blooms and the resulting nuisances. Not treating the problem of nutrients at the source is to transfer them through rivers to dams and other aquatic systems.

Like other regions, in northwestern Algeria, dam waters are suffering from the deleterious effects of pollution; thus the monitoring of water quality is necessary to protect soil, plants, water bodies and human health. When interventions on watersheds are insufficient or late, it becomes necessary to act directly on the water bodies without having first made a precise diagnosis and an overall analysis of the initial nuisances and side effects.

2.2 Treatment and Protection

The treatment and protection theme is covered in Chaps. 5–8. Chapter 5 is titled "Wastewater Reuse for Irrigation Purposes: The Case of Aïn Témouchent Region". The prime objective of this work concerns the characterization of wastewater and purified water of Aïn Témouchent wastewater treatment plant (WWTP), which uses an activated sludge treatment process. The second one is to make a comparison of the analysed parameters with the standards to state if treated water can be safely discharged into the natural environment and reused for irrigation purposes.

To increase the supply of a water resource to face scarcity, authorities must think about how to increase its yield taking into account its quality especially when wastewater is reused. Nowadays, it is well-known that the release of wastewater into natural habitats has severely deteriorated soils and aquatic environments and its reuse in agricultural irrigation have become a constraint particularly in semiarid and arid regions. Actually thanks to the existing advanced treatment processes, pollutant concentrations can be reduced to non-hazardous levels, and water of better quality can be produced not only to minimize environmental impacts but also for other uses that do not require high quality as that of drinking water. Algeria has become aware of the urgent need for the construction of sewage treatment infrastructures in order to recycle water for various uses. Among the treatment plants operated by National Sanitation Office (ONA) through Algeria, some including Aïn Témouchent WWTP are concerned with the reuse of treated wastewater in agriculture. To characterize wastewater (at the entrance) and cleaned water (at the exit) of the WWTP of Ain Témouchent, physical and organic chemical analyses were carried out. This analysis allowed exploring the nature of the existing polluting loads in water and their variations. For safety water reuse, monitoring and regular testing of the clean water were made to ensure the international standards and avoid environmental and health risks.

Consequently, Chap. 6 is dealing with the "Protection of Water Resources in Mining Sites in North-East of Algeria" to show the impact of the mining industry on the environment in Algeria. In Algeria, protection measures have not been applied at the level of active or abandoned mining sites; therefore, the study developed in this chapter highlights the impact of metal exploitations on the environment and human health and proposes solutions to minimize the environmental problems generated by the mining industries in Algeria as an example to help decision-makers and concerning authorities to proceed further with other industries involved in water pollution.

Environmental damage associated with mineral extraction has an increasing impact on the mining industry and the workforce it employs. The mining sector in Algeria is experiencing a real expansion nowadays. This development has led to a real scourge characterizing the degradation of the environment. Indeed, the mining activity generates several sources of pollution such as acid mine drainage and release of heavy metals. Through this chapter, the authors have shown the impact of mercury on the abandoned site of Azzaba located in northeastern Algeria; this

problem has been raging for years. No protective measures were undertaken at the site. Investigations revealed that it turned out that the pollution of the site is of anthropogenic origin. The authors indicated that in addition to the area of Tebessa, Algeria has mining sites favouring the extraction of iron and at the same time generating severe pollutions of draining rivers and soil, which is the case for the mines of Boukhadra, Ouanza and also the Khanguet iron mine, which have been closed for years.

On the other hand, Chap. 7 entitled "Physicochemical and Bacteriological Quality of Surface Water Resources Receiving Common Wastewater Effluents in Drylands of Algeria" aims at determining water physicochemical and biological quality of Wadis receiving common wastewater effluents in the region of Biskra (NE Algeria) [5]. The survey investigates water microbiological quality and examines how water physicochemical factors influence microbiological characteristics in water of the Wadis studied. In arid environments, water is not only a rare resource but also exposed to different types of pollution, primarily from domestic and industrial activities. The authors focus on the assessment of water physicochemical and bacteriological quality of Wadis receiving heavy load of urban effluents in the region of Biskra in northeastern Algeria. This treatise explores the impacts of water characteristics on the spatial and temporal variations of existing pathogenic bacteria in Wadi water. The chapter reports alarming organic pollution of Wadi waters of the region of Biskra, which represent a real risk to the health of riverine populations as well as the aquatic system and its biocoenosis [10].

An overall scheme was adopted to make this investigation successful, including selection of water sampling stations, sample collection and physicochemical and microbiological analyses supported by appropriate statistical analyses [4].

The analysis of water physicochemical characteristics revealed that the Wadis surveyed have poor water quality due to high faecal pollution that exceeds reference standards established by FAO and WHO. Thus, the light was shed on the severity of the environmental situation caused by sewage effluents, including negative impacts on the soil, agricultural lands, crops, human health and the aquatic environment with its associated lifeforms.

Moreover, Chap. 8 is titled "Valorization of Oily Sludge in Arzew Refinery". The main objective of this chapter is to thermally treat oily sludge from the oil industry at the level of the RA1/Z refinery and then make a characterization of sludge by x-rays fluorescence (XRF) to determine the mineralogical composition mass in the form of oxides, e.g. percentages (% SiO_2, % CaO, % Fe_2O_3, % K_2O, etc.). X-rays diffraction (XRD) was conducted for sentencing phases, for example, silica, crystalline or amorphous [11]. Fourier transform infrared spectroscopy in attenuated total reflection (FTIR-ATR) was applied to determine functional groups (e.g. O–H, C–H, C–Cl, Br–C, C–I, C–N, N–H, etc.). Finally detection of heavy metals by atomic absorption spectroscopy (AAS) was carried out. This study aims to determine the sources of heavy metals in industrial wastewater which predicts sludge quality characteristics. The chapter highlighted several origins that can be identified as polluting source including industrial activities.

On the other hand, the refinery station generates another waste (mud) which is rich in oily sludge of toxic nature and carcinogenic and can be neither stored nor put in discharge. The sludge treatment is a difficult process in the fight against pollution. Indeed, the scrubber can resolve this difficult problem that faces many challenges: scarcity of land available for disposal and filing, and adhering to the environmental and public hygiene requirements. Moreover, economically, this problem is illustrated by the importance of the costs it takes both in investment and operating. Oily sludge with a significant calorific value which represents 90% of methane (CH_4) can be considered as an interesting fuel resource. However, the impacts related to its combustion in poor conditions can be drastic and fatal to the environment.

2.3 Development and Future of Water Resources

This theme is covered in four chapters from Chaps. 9 to 12. Chapter 9 is titled "Overview of Water Resources in Steppe Regions in Algeria". Steppe rangeland regions in Algeria are the most suffering lands from water stress. This chapter gives a point situation of actual and future water supply status under the rapid population growth rate and effects of climate change on the renewing of water resources. According to the authors of the chapter, water policy in Algeria in the beginning of the year 2000 focused only on the capital of Algeria "Algiers" and some geostrategic cities, viz. Oran, Constantine, Annaba and Tlemcen. The results of this policy resulted in the realization of 11 desalination stations and a lot of dams located across the country. After the long drought that hit Algeria, another problem appeared in Steppe regions which is the water penury due to losing several water boreholes because of the increase of the drawdown of the water table. This chapter provides an overview of the actual and future situation of water supply, by application of two scenarios, the first one supposes a normal evolution of water production across the population and demographic growth up. The second scenario assumes an effect of climate change which led to a reduction in water production (reduction of rainfall, surface runoff and groundwater recharge). The simulation assumes a simple linear model. The deficit for each scenario was calculated to be about 13% and will start in 2021 with a small rate and achieve 13% at the beginning of 2027. The authority in these regions works to increase the number of Boreholes without taking into consideration the aquifer potentiality. Similar to other chapters of the book, the chapter ends with some recommendations to solve this situation.

Additionally, Chap. 10 is titled "Water resources, state of play and prospects for development in the steppe region of Naâma (Western Algeria)". The region of Naâma is part of the semiarid territory of the South Mediterranean, it undergoes contrasting climatic influences where the rainfall is insufficient and irregular, the inter-annual and seasonal variations are very marked and the intense evaporation and the high temperatures are with a greater amplitude or less contrast. The region is rich in surface and also underground water resources (rivers and Wadis, reserves of Chotts Chergui and Gharbi, groundwater reserves, etc.). It has significant

groundwater potential, especially around El Chergui and El Rharbi Chotts, in Naâma syncline and in Ain Sefra-Tiout Valley. The chapter presents a diagnosis of the current state of water resources and their challenges through the analysis of various natural, climatic and anthropogenic constraints in the steppe region of Naâma (western Algeria). The region is facing serious challenges such as growing water scarcity exacerbated by population explosion and urbanization, resource misallocation, environmental degradation and poor water management that requires to adopt a novel approach of water resources management [11].

Although the issue of water resources is vital, it is still persistent and the levels of agricultural and pastoral production are still rather modest compared to the important needs of a growing region. Consequently, the rational management of water resources is a necessity, even an obligation, in order to ensure a harmonious and sustainable development that requires for its success a combination of technical, economic and financial and institutional solutions. The chapter highlights the necessity to launch economic programmes that respect the efficiency of water use and revise allocations of resources in order to answer the increasing needs in the steppe rangelands of Algeria.

The next two chapters are, therefore, focusing on the development of new water resources.

Chapter 11 is titled "Desalination in Algeria: Photovoltaic power plant for TMM (Tahlyat Myah Magtaa) of Oran as a case study". The chapter is a contribution to the design and the integration of renewable energy sources in the Algerian central power grid, particularly in areas of high human concentration within the scope of a large project. It designs a photovoltaic plant for desalination station "El Magtaa" of Oran in Algeria.

A feasibility study was conducted to provide all the technical and financial elements to the project owner and stakeholders. Also, the chapter estimates expected production (taking into account environmental constraints) and the evaluated possible constraints of the connection to the grid with regard to the location of the site.

The project certainly requires huge investments which will surely influence the cost of producing a unit of water (say one m^3) measures such as the use of local products and optimization of consumption to reduce the cost of water production.

On the other hand, flood forecasting is essential to understand and assess the availability of water resources and to assess the risk of floods [3]. Consequently, Chap. 12 with the title "Hydrograph flood forecasting in the catchment of the middle Cheliff" is focused on the study of the hydrographs of the extreme flood in the middle Cheliff watershed by the analysis of the peak output, the form of the hydrographs, the fall and boarding times, in the aim to understand these hydrographs of hydrological extremes flows and to detect the areas vulnerable to the flood hazard.

Algeria is among Mediterranean countries most vulnerable to floods caused by overflowing streams crossing towns and suburban areas. These floods occur suddenly, with difficulty to predict them, and they are generally linked to intense rainy episodes and are manifesting on middle size basins. The concept of modelling in flood-duration-frequency has been established on an objective basis, and its extension towards ungauged watershed supplies a theoretical frequency description of the

multi-duration of flood quantiles. In addition to hydrological variables, two indices of the watershed flood regime are essential to be determined, which are the maximum instantaneous flow of 10-year return period and flood characteristic duration of watershed "D".

The chapter recorded two or three exceptional peak events of theoretical return period close of the centennial for all stations studied and which flows on the large durations are a little scarcer, even very rare for one of them. Six durations are considered, giving six series of threshold flows between 1.5 and 15 h for the Rouina basin, 2–20 h for the Ouahrane basin, 1.5–15 h for Tikazel basin and 3–30 h for Allala basin. The knowledge of the flow threshold permit to trace the synthetic mono-frequency hydrographs, which are essential components of hydrodynamic model entry in order to determine the risk of any flooding that is characterized by a return period, as the station of Sidi Akkacha (Allala), which is characterized by a very important quintile for the longer return periods, and also the case of station Bir Ouled Tahar (Rouina-Zeddine).

The book ends with the chapter numbered 13 that includes the conclusions and recommendations.

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