Update, Conclusions, and Recommendations for Water Resources in Algeria: Water Quality, Treatment, Protection, and Development

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Abstract Water quality, treatment, protection, and development in Algeria are framed by problems related to water sustainability. Natural resources are at the core of Algeria's sustainable development and are critical to socioeconomic growth. This chapter captures the water quality, treatment, protection, and development in Algeria (in terms of findings and suggestions) and provides ideas extracted from the

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volume cases. In addition, topics were covered by some (updated) results from a few lately published study works linked to water resources. This chapter offers a number of suggestions for protecting resources for Algeria's current problems.

Keywords Assessment, Egypt, Environment, Protection and development, Sustainability, Treatment, Water quality

1 Introduction

Water is one of the most important raw materials in Algeria. In the context of sustainable management of invaluable water resources for the future, Algeria has taken quantitative and qualitative adaptive steps. By implementing a domestic water plan, Algeria aspires to safeguard its water resources and provide a sustainable response to water supply and management problems. This program is consistent with all projects adopted by the Algerian government to improve the quality of its water sector.

This book explores up-to-date information on water quality, water treatment, and water resource protection and development in Algeria. This book addresses the question of how science and technology can be mobilized to make that promise come true. Therefore, the intention of the book is to improve and address the following main theme.

- Water quality
- Treatment and protection
- Water resources modeling
- Development and future of water resources

The next section offers a brief overview of some of the most recent (updated) water resource studies in Algeria's important outcomes. Then, the key results of the book chapters are summarized as the primary suggestions for researchers and decision-makers. The update, conclusions, and recommendations presented in this chapter come from the data presented in this book.

2 Update

The following are the major updates for the book project based on the main book theme.

2.1 Water Quality and Modeling

One potential practice for water resource modeling is identified: the Kalman filter for spatiotemporal modeling and prediction of Algerian water resource variability. The chapter is an overview of water resource modeling for ends of prediction in Algeria. It focuses on a particularly interesting type of model that can support not only the stochastic nature of the hydrological processes but also their temporal variability as well as the nonlinear character of the hydrological system. Such models are mostly required in water resource design and management because they provide a helpful tool for decision- and policy-makers in Algeria. The objective is to showcase some of the recent results regarding the extent of applicability of discrete Kalman filter (KF) to the modeling and prediction of water resources in Algeria. For this end, two important hydrological variables have been investigated: rainfalls in the Chéliff watershed and stream flows in northern Algeria. KF is one of the most popular filters in this area. It relies on the recursive least squares concept. It is well-known in many other fields than hydrology that the KF optimality provided the assumptions of linearity and white Gaussian noise. The major advantage of KF is to provide the prediction error covariance an indicator of the filter accuracy. In addition, its calculation algorithm works in the temporal domain with a recursive nature and has an optimal estimator in the least squares concept. Another aspect of its optimality is the incorporation of all the available information on the system, measurements and errors in an adaptive operator, which is reset each time a new measurement becomes available.

Additionally under this theme, two chapters are identified in the book connected to the current status of water quality. The first study predicting water quality indicators from conventional and nonconventional water resources in the country of Algeria is "adaptive neuro-fuzzy inference systems versus artificial neural networks." Monitoring water quality is of great importance and mainly adopted for water pollution control of conventional and nonconventional water resources. Monitoring wastewater treatment plant (WWTP) using online sensors has become an essential and crucial task to handle rapid and seasonal variations that occur during all the months of years [1]. Consequently, real-time supervision of the process of WWTP is nowadays a challenge [2]. To deal with these challenges, WWTP must be highly efficient [3]. Evaluation of the WWTP performances is mainly based on the measure of water quality indicators (WQI), which are generally hard to measure regularly. In the last few years, soft computing models have been largely employed for modeling and forecasting WQI in several water ecosystems. Chemical oxygen demand (COD), biochemical oxygen demand (BOD), and dissolved oxygen concentrations (DO) were the most important WQI that have received great importance, and modeling chemical oxygen demand in WWTP is broadly discussed in the literature [4].

The second study is linked to the organic chemical characterization of water of the northwestern Algerian dams. To ensure its independence and guarantee its water resource needs, Algeria has already taken this problem very seriously. Surface water

collected in dams may be polluted and contain important levels of salts, toxic ions, heavy metals, and organic residues. Accumulation of these pollutants when in water and soils may cause a threat to agricultural production and the environment. Organic matter content in water generally comes from crop wreckage, food waste, other degradable solid wastes, and fecal matters. Algal and phytoplankton growth is enhanced by nutrients that are supplemented by fertilizers which finally results in eutrophication [5]. Many studies have been published concerning the assessment of water quality in rivers [6] and dams [7–9] using physical, chemical, and biological parameters.

2.2 Treatment and Protection

Four approaches related to treatment and protection are identified in this book. The first approach identified is the wastewater reuse for irrigation purposes: the case of the Aïn Témouchent region. Anthropogenic effects like municipal waste discharge and agricultural and industrial activities play a major role in determining the surface water quality in a given region. Nowadays, existing treatments can reduce the pollutant concentrations to non-hazardous levels and make it possible to obtain water of better quality from wastewater. The treatment and disposal of wastewater do not only minimize environmental impacts but also allow uses for irrigation purposes and those that do not require drinking water (e.g., recreational activities, industrial uses, aquifer recharge, firefighting, aquaculture, domestic uses, etc.). In wastewater, phosphorus can come from human metabolism, washing and cleaning products, and orthophosphates from the hydrolysis of inorganic phosphate. Phosphorus released from wastewaters into watercourses can cause undesirable effects, such as eutrophication and its related effects [10] which leads to profuse algal blooms, excessive growth of aquatic plants, deoxygenation, and water purification problems [11]. The purpose of measuring EC is to control the quality of the wastewater; it reflects the degree of overall mineralization and tells us about the water salinity [12]. Its measurements can be used to monitor the processes in wastewater treatment that cause changes in conductivity such as biological phosphorus and nitrogen removal.

The second study identified is the protection of water resources in mining sites in northeast of Algeria. Mining is a sector of activity essential for global economic development. Metals and minerals extracted by the mining industry are integrated into several consumer goods. Given the increase in the population and the demand for these goods, the mining industry is growing globally for a few decades. This type of industry is responsible for several impacts during each phase of the mining process. In particular, it is during the exploitation phase that the natural ecosystems, located above the deposits, are destroyed by the elimination of soil and vegetation and the establishment of storage sites for discharge mining. Thus, the extraction of mineral resources has a definite duration, whereas the associated environmental impacts can be visible indefinitely if no corrective measures are taken.

The third method identified is the physicochemical and bacteriological quality of surface water resources receiving common wastewater effluents in the drylands of Algeria. The assessment of water quality and pollution of surface water resources is crucial to maintain the integrity of aquatic environments. Nature and living beings are increasingly suffering the consequences of pollution generated from industrial development and population growth. Water pollution affecting rivers, seas, groundwater, and lakes is the result of the discharge of wastewater in nature without or with insufficient treatment, thus causing degradation of habitat and disturbance of ecosystem balance. Water pollution is one of the serious problems of modern civilization as it continuously concerns people and governments. Increasing pollution is spreading and threatening development efforts and the health of humans and their environment, mainly water resources [13]. On the other hand, the reuse of wastewater in crop irrigation [14] and its by-products such as sewage sludge in land fertilization [15], provided adequate treatments and pollutant removal are made [16], may solve partially issues related to water shortage in arid agriculture and food insecurity at drylands [17]. Another study focuses on the physicochemical and biological quality of the surface water of Wadis of Biskra (Algeria's No. 1 agricultural hub [18]).

The last approach identified is the valorization of oily sludge in the Arzew refinery. The environment is one of the pillars of sustainable development. For a long time, it was forsaken with the profit of the economic and social one. It is obvious today that the company and the economic activities will have to be built on a better balance of these three realities closely dependent. It is about a new and considerable challenge, which is carrying opportunities and innovations [19]. Other sources contribute to the pollution of the natural environment; one is the sanitary and domestic waters conveyed in underground networks separating toward sea [20]. The sludge treatment is a difficult phase in the fight against pollution. Moreover, the economic importance of this problem is illustrated by the importance of the cost. Both in investment and operating, it can represent oily sludge with a significant calorific value, which represents 90% of methane that can be considered as an interesting fuel. The impact related to its combustion in poor conditions can be important.

2.3 Development and Future of Water Resources

Four methodologies related to the development and future of water resources are identified. The first study is an overview of water resources in steppe regions in Algeria. Water resource management is an essential step in the national water resource planning. However, the overexploitation of groundwater as a result of population growth and industrial and agricultural emergent activities makes the planning operation more complicated. In the field, two questions appear in the mind: What are the Algerian water resources' potentialities? Moreover, what are the procedures to avoid the rapid depletion of these resources? Because of many

reasons, the answer to these questions is not dependent only on the actual and the available statistics on water resources. The answer is dependent on the actual climate situation, the actual population growth, and the actual availability of water. The Algerian steppes have seriously faced more episodes of drought in the last decade. The lack of water is the principal source of this drought (meteorological drought). Furthermore, the Algerian steppes have great importance in the national strategy of development (higher plate development program). The rapid demographic growth applies high pressure on water resources [21]. Since the last few decades, the region's water resources were limited in terms of quantitative availability and quality.

The second study acknowledged is water resources, state of play, and development prospects in the steppe region of Naâma (Western Algeria). The issue of water resources is vital. It is at the center of a large number of interests: food security, agriculture, biological diversity, desertification, land use planning, poverty, health, peace, conflict, etc. However, the risks of degradation of agro-ecological resources, including water resources, are still persistent, and levels of agricultural and pastoral production are still rather modest compared to the significant needs of a growing region. The Naâma region contains significant underground water potential that has been little exploited, especially in the steppe plains around the chotts (El Chergui and El Gharbi), in the Naâma syncline. Geographically, the department of Naâma is a vast territory with stratified reliefs consisting of three large geographical units [22]. It has relatively large water resources and indeed benefits from many natural assets: heavy rains, a mountain water tower with large infiltration areas and snow-capped peaks, perennial rivers, and large underground aquifers of continental intercalary (Albien). The integrated water management approach will contribute to sound planning taking into account the various social, economic, and environmental interests. It emphasizes the participation of stakeholders at all levels in the development of legal texts and emphasizes good governance and effective institutional and regulatory arrangements to promote more equitable and sustainable decisions. The approach must be implemented using the economic, institutional, and technical tools to increase the efficiency of irrigation, improve the operation and maintenance of perimeters, improve drainage, and reduce soil salinity.

The third study recognized is desalination in Algeria: photovoltaic power plant for TMM (Tahlyat Myah Magtaa) of Oran as a case study. The future development of water resources depends on solutions characterized by high energy consumption, for example, seawater desalination, the reuse of wastewater, and the introduction of drip irrigation. The development of the water sector will, therefore, be closely tied to the development of the energy sector. This sector must conduct a large-scale program of studies to understand the current and future impact of climate change, identify and quantify associated costs and its interactions with water and energy, and specify adequate solutions for adaptation. Mobilization of nonconventional water resources (desalination and wastewater reuse) will be a strategic component of future water policy. The development of unconventional resources and the management of water demand will increase more the energy consumption of the water sector. The production of electricity using a photovoltaic system connected to the grid is of great

interest to developing countries, especially for countries suffering these last years from the quality of their central grid. Photovoltaic can have undeniable advantages, particularly for its cleanliness and durability. Also, it can be used in various applications such as agriculture and desalination, etc.

The last study known is flood hydrograph forecasting in the catchment of the middle Cheliff. Algeria is among the Mediterranean countries which are the most vulnerable to floods caused by overflowing of streams crossing towns and suburban. The impact of climate change on flood peaks was the subject of several studies. However, a flood is not characterized only by its peak but also by the time, duration of the tip, as well as the rise time and shape of the flood hydrograph according to geographical distribution, leading to an understanding of these extreme hydrological hydrographs and to detect areas vulnerable to flood hazards. The Flood-duration-Frequency observed chronic Q(t) rate offers a theoretical definition of multi-term flood quantiles, explicitly fulfilling the needs of the catchment's integrated hydrological modeling. Although some studies had to be devoted to F-d-F models, this approach remains not much used. In Algeria, this method was successfully applied in some basins [23]. Many studies on the genesis and the dangerosity of the flood have been carried out for a few years in the world [24, 25] and in Algeria [26]. Finally, the study also went on the determination of the peak output of floods. For that, the F-d-F analysis was requested to define mono-frequency synthetic hydrographs (MFSH) able to characterize the behavior of a flood for a given period of return.

3 Conclusions

Several results taken from this book were obtained by the editorial teams. The chapter draws significant lessons from the book cases in relation to methodological concepts, specifically the covered topics of water quality, treatment, protection, and development in Algeria. This chapter provides the present problems faced by the water resources in Algeria. These outcomes are vital to Algeria's improvement of water resources. Based on the materials listed in all areas of this volume, the following findings could be reported:

1. MLPNN, MLR, and three ANFIS models, namely, ANFIS_GP, ANFIS_SC, and ANFIS_FC, were developed to model two water quality indicators: (1) *chemical oxygen demand* (*COD*) and (2) dissolved oxygen concentration (DO). The models were developed using several water quality variables measured at daily time step at WWTP and DWTP, respectively. Some conclusions can be drawn and are summarized as follows: by comparing several combinations of the input variables for modeling DO concentration, the best results were obtained by the ANFIS_SC with TE, pH, SC, and TU inputs, followed by the ANFIS_FC in the second order, ANFIS_GP ranking third, MLPNN ranking fourth, and the MLR model in the last place. In regard to modeling COD, the results showed that the ANFIS_SC with TE, pH, SC, and SS as inputs had the best results, and it can be used to estimate COD with very acceptable accuracy,

followed by the MLPNN, ANFIS_GP, ANFIS_FC, and MLR, respectively. Another *conclusion we can draw is that the accuracy of the proposed models is mainly dependent to the selection of the input variables. To obtain good* prediction *accuracy,* it is necessary that all the variables be included for the models.

2. Surface water quality data for 14 parameters collected from the monitoring of 10 dams located within 2 northwestern Algerian watersheds (Macta and Tafna) were analyzed monthly. The waters of all dams were alkaline, with pH values ranging between 7.01 and 8.97. The highest DR contents were found at Macta watershed. The maximum yearly average (3,161.7 mg L^{-1}) was recorded at Sarno dam located upstream of the confluence of Mekerra and Sarno wadis. In the other Macta dams, yearly averages were between 1,101.7 and 1,858.3 mg L^{-1}. Tafna watershed registered lesser contents varying between 279.2 mg L^{-1} at Meffrouch dam and 1,081.7 mg L^{-1} at HB. The calculated organic pollution index values during the study period evidenced the pollution state of the dams. They indicated moderate to very strong pollution in the water of the two watersheds. In Tafna dams, OPI averages of SA, Meffrouch, and BB dams exhibited moderate organic pollution. As for Sikkak, pollution is considered to be moderate from January to April and strong during the remainder of the year. The water of HB was strong to very strongly polluted. Waters of Fergoug, Ouizert, Cheurfa, and Bouhanifia dams were generally strongly polluted except that of Sarno dam, which indicated strong pollution only during May and December months. Indeed, the water of the two watersheds was more or less difficult to biodegrade.
3. Temperatures and pH values at the inlet and outlet of the WWTP show no significant differences and are generally in compliance with wastewater discharge in receiving mediums and reuse standards for irrigation use. Wastewater conductivity values are between 1,240 and 2.730 μS cm^{-1}. They vary after purification to reach values ranging from 1,460 to 2,730 μS cm^{-1} and can, therefore, be used for crop irrigation according to the standard recommended by WHO. The values of the COD/BOD_5 ratios for approximating the biodegradability of organic matter in a given effluent indicate that this wastewater is domestically dominant and, in general, easily biodegradable. This biodegradability is well evidenced by the values of the COD/BOD_5 ratios which vary between 1.08 and 2.70. The analyses also revealed significant decreases in BOD_5 and COD. In treating water, they are between 2 and 8 mg L^{-1} and 18.7 and 43 mg L^{-1}, respectively. We note, however, an increase in the dissolved oxygen concentration of treated water (6.49–9.63 mg L^{-1}) compared to that of wastewater (0.46–4.46 mg L^{-1}). Elevated suspended matter content in wastewater (84–464 mg L^{-1}) decreases in low concentrations in treating water. The analyses also revealed significant nitrogen pollution. The high Kjeldahl nitrogen concentrations in raw water (31.81–79.42 mg L^{-1}) decrease after treatment to reach values between 3.01 and 11.6 mg $L^{-1}$and are therefore within the standards of discharge in the environment and that of wastewater reuse in crop irrigation. Phosphorus is present in treating water with concentrations ranging

from 1.09 to 4.86 mg L^{-1}. These values are in line with the JORA effluent discharge standards and the FAO and WHO standards for irrigation use.

4. The management of waste from mining activities and tailings and waste rock usually represents an undesirable financial burden for operators. Generally, the mine and ore processing plant is designed to extract as many marketable products as possible, and tailings and environmental management as a whole is then designed as a consequence of the mining stages. The choice of tailings and/or waste rock management method to be applied depends mainly on an assessment of three factors: cost, environmental performance, and the risk of accidents.
5. It is also determined the water quality of arid wadis receiving wastewater in the region of Biskra. The results of water physicochemical and bacteriological analyses revealed that the values of several parameters exceed the standards established by FAO and WHO, which indicates large fecal pollution. In effect, the high level of bacterial loads indicates fecal pollution of all the study wadis. The findings show that wastewater effluents pose serious environmental contamination issues and health risks that can affect human communities, agricultural lands, crop products, and aquatic life forms that rely on water of the wadi system. The main risk is associated with exposure to pathogenic biological agents, including pathogenic bacteria, helminths, protozoa, and enteric viruses. High fecal contamination induces drastic changes and deterioration in water characteristics that cause the collapse of aquatic ecosystems.
6. At the time of the realization of our memory of the end of the study, we became aware of the importance of the purification plant, with the objective of purifying oily water so that they are not directly rejected. They can generate serious environmental problems and handles the public. The exact composition of muds varies according to the origin of oily water. Muds are very rich in organic matter (between 50 and 70% of matter dries), which supports the proliferation of microorganisms which multiply and break up the organic matter. In the absence of sufficient ventilation, decomposition of organic matter releases greenhouse gases (carbonic gas. methane. etc.). This situation illustrates clearly that an action plan became necessary to rehabilitate a system allowing adequate exploitation of muds by respecting the standards of environmental protection. The calorific values of organic matter of dried mud are high. The use of alternative fuels makes it possible to diversify energy resources and to reduce these costs. The organic components which will be exposed to heat treatment with temperatures of 200°C and 600°C will be burned completely, while the mineral components which will undergo a chemical conversion will integrate into clinker without deteriorating their excellent quality.
7. Due to the important socioeconomic development in recent years, the new sustainable development strategy in Algeria is a real challenge that is fundamentally based on rigorous management of water resource potential to cope with all forms of water demand for domestic, agricultural, industrial, and environmental needs. The present chapter is presenting some of the recent results in the context of the stochastic hydrological process modeling and prediction in the

case of time-varying linear systems. It concerns water resources in the northern part of Algeria, where discrete Kalman filter technique has been applied to the modeling and prediction of stream flows and rainfalls in a number of sites simultaneously (multisite) for each of the monthly and annual scales. The developed operators have the particularity of automatic self-adaptation as soon as a new measure becomes available. This is an advantage of the KF algorithm recursive character that can be used in real-time predictions. As a result, optimal stream flow and rainfall predictions are obtained considering time variations of the underlying hydrological generating processes, as well as their stochastic character. The obtained predictions can be appreciated from a temporal point of view, where observations and predictions in a single site are obtained during a period of time, but can also be extended to any further step where observation is available. These predictions can also be appreciated from a spatial point of view, where observations and predictions in all considered sites are obtained during a period of time, but can also be extended to any other site where observation is available. One of the most important advantages of the developed operators is to provide the error prediction covariance matrix with certainty at each calculation step. This is of great interest because it constitutes a measure of the prediction accuracy at each step calculation. The accuracy of the predictions, and consequently the suitability of the operators, has also been checked by the prediction relative error in percent whose overall average value is less than 10% which is highly acceptable. A slight tendency for operators to overestimation for rainfalls and underestimation for stream flows has been observed. Another advantage of the developed operators is that the algorithm may be initiated with very little objective information and the prediction is obtained in time domain. This is of great interest because it offers a real-time forecasting possibility. The developed operators are interesting because they can help policy- and decision-makers in water resources in Algeria acting efficiently for better management and sustainable development of such resources in the country.

8. On the other hand, a simulation of the situation of groundwater resources in the next 10 years by introducing an actual parameter of exploitation was conducted. Two scenarios have been implemented to show the evolution of water demand and water deficit during the simulation period. The results show that the water deficit in the coming years is about 13% by taking a water demand reference for a population of 100 L/capita/day. The situation may be complicated in the future years by groundwater quality degradation and reducing the mobilized water from dams. An emergency plan must be implemented to secure the population of such kind of regions from water shortage in the medium and long range. Some of these projects propose [7] the transfer of desalinated water from the north [16], water reuses [14], reduction of the loss of water in distribution networks [22], and optimization of water distribution by using the remote control of water production facilities to avoid leakage in the distribution network.
9. The department of Naâma is a region with a pastoral and agro-pastoral vocation that has considerable pastoral and underground water resources. With an arid

climate and the absence of structures for mobilizing surface water, the department of Naâma is mainly supplied with groundwater. The water resources of the department are appreciable but require to be evaluated in a precise way to ensure their use in a rational and sustainable way. The situation in the department of Naâma is worrying where water must be at the center of the concerns of local authorities, management bodies, users, and all citizens. Faced with this situation, and in order to avoid potential conflicts, we must involve all those involved in water, where individual practices must become more aware and more respectful. The major concern for the sustainable safeguarding of the water resource in these arid regions is to implement a strategy of safeguarding and exploitation rationally by resorting to planning based on short-, medium-, and long-term forecasting models for detecting trends and future patterns of water use, socio-economic development, and population growth.

10. To cope with population growth and economic development, energy and electricity demand in Algeria will increase substantially between now and 2030. In the absence of a rigorous energy efficiency policy, the energy sector's water requirements will be also envisaged in terms of electricity generation in hydroelectric plants (dams) and as makeup water for cooling in classic thermal power stations and cleaning for the hybrids stations (solar stream) particularly for those located in the country's interior (Sahara). Solar photovoltaic is used very widely and for a long time for pumping water, for example, the site of El Hamrawin in Egypt commissioned in 1981. This station used the mechanical energy of a thermodynamic solar pump (SOFRETES), now replaced by a photovoltaic generator. For desalination, there are quite a few realizations in photovoltaic, probably due to high costs. However, we can mention in Algeria the unit of Hassi Khebi with reverse osmosis associated with a PV generator. Solar thermal energy is economically more competitive. There are already a significant number of achievements. In the Mediterranean, there are solar stills particularly hothouse types in Greece and Spain. Tunisia provides for the use of solar energy in 45 new desalination plants in areas of the South which are Medenine, Tataouine, Kébili, and Ksar Ghilane. Finally, Tahiyat Myah Magtaa Spa is in front of a very promising project of technology watch which can be combined with other projects such as the SSB (Sahara Solar Breeding) project in order to optimize the investment and its damping as quickly as possible.
11. The flood regime modeling has been established according to quantiles of threshold flows coming from the statistic adjustment, which is compared with flood regime characteristics of the watershed *(QIXA10 and D),* to different counterparts quantiles from F-d-F models. The relative quantiles with low flows are better reconstituted than equivalent or superior quantiles to *QIXA10*. The converging model applied to tested basins constitutes equivalent values to those which could be obtained by adjustment on each duration taken separately. In general terms, using F-d-F approach seems to be well-adapted, and it is able to take into account duration, which is the essential notion when we are speaking about flood; it, therefore, considers "variable time step." So the description in flow-duration-frequency, whatever be the formulation, has several uses:

estimation of flood quantiles in middle flows or threshold flows to estimate hydraulic works, insertion in a flood regime typology, definition of hydrologic reference scenarios for flood risk estimation, validation of hydrologic model outputs, and characterization of the regime evolution of high water level. The knowledge of the flow threshold made it possible to trace the mono-frequency synthetic hydrographs, which are essential components of hydrodynamic model entry in order to determine the risk of a flood characterized by a return period. The station of Sidi Akkacha (Allala) is characterized by a very important quantile for the longer return periods, which follow the station Bir Ouled Tahar (Rouina-Zeddine).

4 Recommendations

A key component of Algeria's water resources is the ability to adapt to future issues. We argue that water resources need integrated flexibility to achieve this goal. The editorial teams observed certain aspects that could be explored for further enhancement throughout this book project. Based on the contributors' results and findings, this chapter provides several recommendations for future scientists to go beyond the scope of this book.

1. Results obtained in the present study highlighted many points that need to be addressed in the future. Firstly, the quality of data must be improved and the list of variables measured should be extended to other variables, notably to include chemical and physical variables that can be good predictors for COD. Secondly, the proposed models should be applied to other WWTP for further comparison of the models' performances.
2. To ensure good water quality in order to preserve dams against pollution, several measures must be taken. Following the observations made during the processing of the acquired information, it is important to frequently analyze other water parameters at watershed and dams, such as heavy metals, to get more information and to identify the emerging water quality issues and the extent to which existing criteria and recommendations can address these problems. More accurate monitoring is recommended for watercourses, and setting up mandatory regulations for polluters by requiring them to clean their wastewater by sewage treatment plants before pouring them into streams is needed. Necessary measures must be taken to avoid the eutrophication of the dams which is the consequence of the poor quality of water and the presence of pollution. It is also important to create treatment plants for each dam inlet regardless of the destination of these waters, as it is necessary to adjust the treatment in relation to the water quality and according to their uses.
3. It is well-known that wastewater should be disposed of in a manner that it should not be harmful to the environment and human health. Currently, although implemented devices allow the elimination of pollutants contained within this effluent, reuse of wastewater from WWTP could cause unhealthy problems. It is

necessary to ensure the performance of the treatment techniques used by performing complete physical, chemical, and bacteriological analyses of the treated water. As for reuse for irrigation, monitoring and frequent testing of the clean water should be made to ensure the international standards and maximum safety levels. An increase of awareness at all levels with particular emphasis on WWTPs and among farmers is required to mitigate the risks that may be incurred by the population. Farmers should use appropriate crops with treated water and suitable irrigation techniques.

4. Mining operations generate wastes that can be harmful to the environment if they are disposed of without adequate treatment. The monitoring of an abandoned or active mine site is mandatory. This monitoring is aimed at preserving the environment and especially natural ecosystems. Therefore, studies must be carried out, whether ad hoc and local or recurrent and national, to measure the levels of metal deposits. These studies measure the deposition either directly (by placing collectors close to the ground) or indirectly (by accumulation in soils, sediments, living organisms). The implementation of a program allows an estimate, in background situations, of metal deposits (iron, mercury, nickel, lead, arsenic, zinc, etc.). This program has the following objectives: monitor the variations of metal deposits in the natural environment; evaluate the extent of contaminated areas by using the ArcMap application; identify the local origin of the sources of emissions; set up a rehabilitation plan for closed or abandoned sites; and monitor improvements resulting from the application of rehabilitation plans to reduce the impact of metal emissions.
5. In perspective, in order to limit the risks of water pollution in wadis, it is recommended to (1) install wastewater treatment plants before releasing it into the environment in order to preserve water quality in the natural environment and thus sustain life forms and ecosystem integrity; (2) divert sewage collectors and discharges sites away from agricultural lands to reduce the risk of soil contamination and thus produce healthy agricultural products; and (3) periodically monitor water quality to prevent events of high contamination of hydrosystems receiving polluted water. Under conditions of water scarcity in drylands, a wise water management policy needs to promote the increase in agricultural production with less water. This can be achieved through the rationalization of irrigation and drinking water use and the improvement of irrigation systems with cutting-edge techniques of water saving. The reuse of the adequately treated wastewater in agriculture irrigation is a promoting practice to save natural water resources for other healthy uses. Since arid agriculture is often associated with land degradation and soil salinization, biosolids produced by wastewater treatment plants are indicated to increase soil fertility with organic matter and improve several soil proprieties and also alleviate the negative effects of soil salinity and water stresses on the crop plant.
6. As an example, the substitution of 13% of the raw material by ashes enables us to eliminate a quantity of 65,000 t/year knowing that annual production of cement in a cement factory (e.g., cement factory of Saida) is estimated at 500,000 t/year cement with ashes obtained at 900°C, which will be used preferably in the

nonexposed works. Finally, it can be completely said that the study of valorization of muds eliminates this waste in an exemplary industrial process on the ecological and economic level.

7. The recommendations to be considered should focus on the following areas:
   Undertake the necessary studies (hydrogeological, hydrological, and bacteriological analyses) to determine with precision the real water potential across the department.

   Estimating the volumes stored and not yet exploited, notably the synclines of Naâma and Ain Sefra, the Ksour Mountains, as well as Chott-Gharbi and northeast of Mecheria.

   Learning how to manage the water resource in the perspective of sustainable development is learning to control its scarcity but also its excesses, to ensure the supply of drinking, agricultural, and industrial water.

   Water development and management should be based on a participatory approach, involving users, managers, planners, and policy-makers at all levels.

   Quantitative and qualitative assessment of water resources and the planning of the development of hydraulic infrastructures.

   Implement measures to minimize network losses (supply, storage, and distribution) by modernizing and expanding infrastructure.

   Rehabilitation and optimization of infrastructure by better management of pumping stations with a policy of preservation, and effective and continuous maintenance of the equipment of dewatering is supervised by qualified personnel with the ability to provide for any failure.

   Improve the water economy by adapting agricultural practices to local climatic conditions and by using new irrigation techniques.

   Promote water purification technologies, which aim to find the mechanisms for the extension of the rational exploitation of water and the recycling of wastewater and their exploitation in the agricultural or industrial fields.

   Integrating climate change into water resource management strategies – adoption of a strategy to increase the storage of water by the construction of hydraulic structures.

   Adaptation of the legal and institutional framework of water.

   Develop and improve public information and specialized education and training for integrated and sustainable water management.

8. The mono-frequency synthetic hydrograph is not observed hydrograph. They have the characteristic of being single frequency; regardless of the length considered, the flow continuously overwhelmed by the hydrograph, which is a quantile debit same frequency threshold. This property ensures consistency between hydrograph and the average flow rate corresponding quantile. The observed flood events in the river could not be described in terms of frequency or return period for the reason that they vary according to the period over which we analyze the phenomenon observed. For this reason, it seems irrelevant to analyze the flood risk on the basis of an actual flood that can be pessimistic and optimistic peak volume or vice versa. The contributions to the hydraulic model will be calculated simply from QdF models. If working steady, reading the

maximum instantaneous flow rates obtained for different return periods gives the rates corresponding to the inputs of hydrodynamic models (such as Saint-Venant). If working in a transient state, it is first necessary to build a single-frequency synthetic hydrograph. Another common use of a single-frequency synthetic hydrograph is in flood routing in order to determine the height poured through a spillway of a dam because this hydrograph is also a hydrometric characteristic of the watershed.

9. In Algeria as well as in other countries (e.g., European countries), monitoring programs are needed to check the quality of wastewaters and to evaluate wastewater treatment processes. This will need to be done in order to achieve high water quality standards of Algeria's treated wastewaters and surface waters. In addition and considering future agricultural uses of water, reuse of a good quality of wastewaters is needed to avoid plant uptake of the contaminants present in wastewaters and to keep food crops and population in good health particularly for pollutants such as pharmaceuticals, personal care products, and surfactants that are present in wastewaters.

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