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Editorial: Integrated water management for enhanced water quality and reuse to create a sustainable future

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Editorial: Integrated water management for enhanced water quality and reuse to create a sustainable future

Safe drinking water and sanitation are very important for the survival of human life. With the rapid proliferation of industries, growth in population and different forms of pollution, i.e. in water, air, soil and sediments, the living environment and the ecosystem is constantly polluted. In this context, integrating different water resources for enhanced water quality and reuse is important to solve the persisting problems and challenges in developing and the developed nations. Integrated water management offers environmental, economic and social benefits because it aims at maximizing the existing resources and prevents further depletion of the ecosystem.

In this special issue, a total of 22 papers were selected for publication from an open call for papers in association with the 13th International Conference on Challenges in Environmental Science and Engineering, CESE-2020. These papers covered the following aspects as illustrated in Figure 1: (i) the performance of different bioreactor configurations for wastewater treatment, (ii) rain water harvesting, (iii) water/wastewater reuse, (iv) the application of mathematical models, neural networks and remote sensing for water quality monitoring, treatment plant performance prediction and water resource management, and (v) the implementation of the water-energy-agriculture concept in practice.

Alsulaili & Refaie (2021) applied artificial neural networks (ANNs) for predicting the performance of wastewater treatment plants (WWTPs) in Kuwait using temperature, pH, conductivity, and BOD as the input parameters. According to the results, increasing the number of model inputs beyond three did not enhance the ANN performance, while the influent BOD and conductivity showed the highest effect on the effluent water quality. The results from sensitivity analysis showed that the influent COD had the highest impact on effluent BOD. The authors recommended ANN model as a reliable option for the intelligent control and monitoring of WWTPs in practice. In a study aimed at water quality monitoring for timely decision making in Namibia, Kapalanga *et al.* (2021) used reflectance values and field measured water quality data to develop regression analysis-based retrieval algorithms. The authors used turbidity, total suspended solids (TSS), nitrates, ammonia, total nitrogen (TN), total phosphorus (TP) and total algae counts as the major water quality parameters. It was observed that the turbidity levels exceeded the recommended limits for potable water, while the TN and TP values were within the acceptable values. According to the authors, an assessment and monitoring of water quality using the combination of remote sensing and in-situ measurements will help to provide a good estimate of the water quality. Furthermore, the authors had also used remote sensing as a framework for continuous monitoring of water quality in Olushandja Dam (Namibia). Another study also used ANNs for predicting the removal of heavy metals, i.e. Cu (II), Cd (II) and Pb (II) from synthetic wastewater in a rotating biological contactor (RBC) (Kiran *et al.* 2021). The authors used a feed-forward back propagation neural network to predict the removal of heavy metals and COD using 90 data sets obtained over a period of three months from the RBC. Through vigorous trial and error for training and testing, and by proper optimization of the internal network parameters, the authors ascertained a network architecture of 2-12-2 and hydraulic retention time (HRT) as the most sensitive input parameter for heavy metal and COD removal in the RBC.

Garin *et al.* (2021) conducted a survey in a French wine-growing region where the public authorities were considering irrigating fields and green spaces with treated wastewater. The authors conducted 845 face-to-face interviews with potential consumers and the following interesting results were envisaged in their study: (a) attitudes and intended behaviours were driven by disgust, environmental sensitivity, risk perception, and type of water reuse, (ii) working women more reluctant than men to wastewater reuse, (iii) the farmers rejected the idea of wastewater reuse, and (iv) with the help of proper communication, farmers could strengthen the social acceptability of wastewater reuse, but with a loss of their wine customers. In this work, the authors clearly presented the attitudes of the consumers buying their fruit (i.e. the grapes), vegetables and wines in this area towards the implementation of a wastewater reuse project. The authors also mentioned that the reluctant group, significantly less open to the media and made suspicious by health scandals, will be difficult to convince regarding the

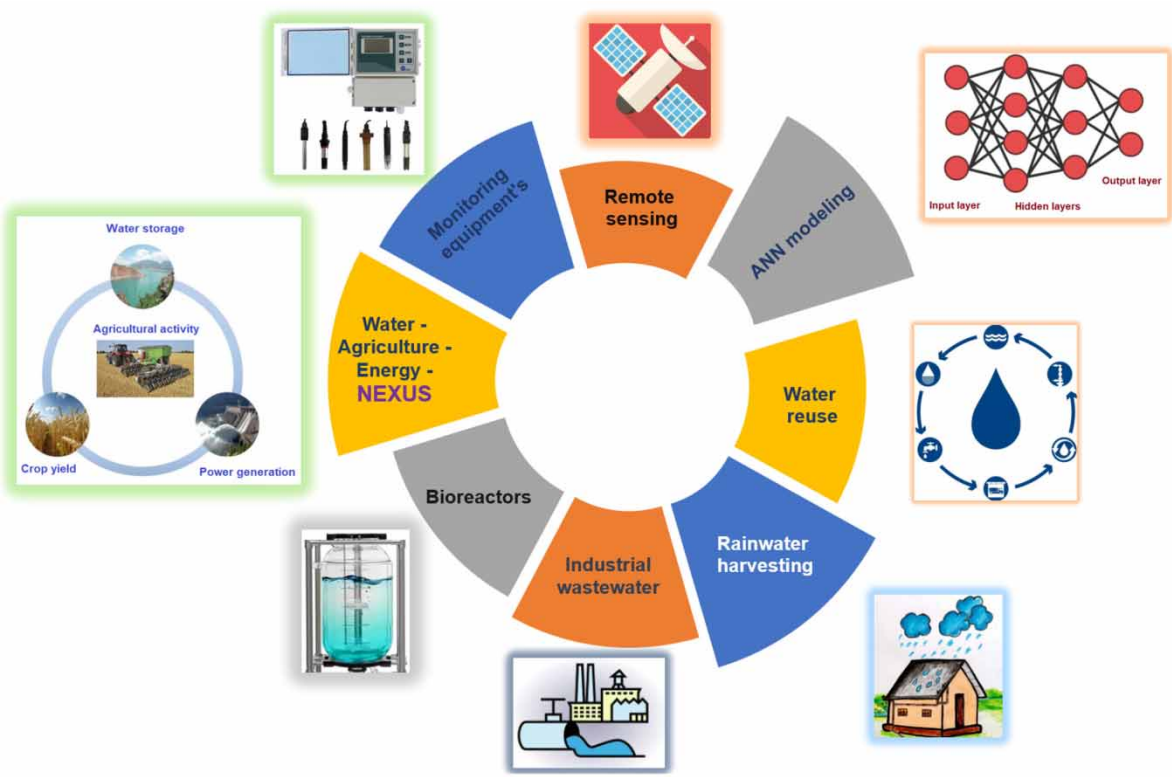

Figure 1 | The application of environmental concepts, technologies and modelling tools for environmental sustainability.

implementation of any wastewater reuse projects in the wine-growing region. In another questionnaire-based study, Vasudevan & Natarajan (2021) prepared structured questionnaires and conducted a survey to realise the awareness of people about improving the rainwater harvesting (RWH) infrastructure in Tamilnadu, India. The authors formulated 45 multiple-choice type questions for the survey under various categories such as demographic details (11%), details about source of water (11%), access to financial support systems (20%), awareness on water quality and treatment (22%), and technical know-how about the operation, troubleshooting and cleaning protocols (36%). The results from this study showed that a majority of the people use harvested water for domestic purposes either collected from rooftops or from the porch/garden, while some people prefer direct groundwater recharge. Furthermore, this study also highlighted an important concern from the people for improved water quality from RWH storage tanks with the help of a treatment step before direct consumption. Thus, the authors recommended that groundwater recharge has to be approached with caution to improve the priority-wise usage of the harvested rainwater and an integrated public-private partnership for RWH has to emerge in India with due consideration for eco-socio-economic variability.

Taylor *et al.* (2021a) determined the suitability of waste activated sludge (WAS) and algae produced from a brewery effluent treatment system as a fertiliser in agriculture. In this study, the change in soil characteristics and the growth of a crop fertilised with WAS or algae was compared with a conventional inorganic fertiliser. It was observed that, Swiss chard production was similar when fertilised with fertiliser, WAS or algae and both WAS and algae increased the soil's sodium absorption ratio. Furthermore, the soil pH, exchangeable acidity and electrical conductivity were similar between all fertiliser treatments, while the soil phosphorus and potassium concentrations were higher in the inorganic-fertilised soil compared with algae or WAS fertiliser soils, respectively. Besides, the authors also observed that the nitrogen applied to the soil from algae and WAS biomass leached out of the soil less than the nitrogen supplied by inorganic the fertilisers. In another study involving algal biomass, Blanco *et al.* (2021) studied the effect of using anaerobically digested gelatin industry wastewater as a culture medium for the cultivation of *Chlorella vulgaris* microalgae in bubble column photobioreactors (PBRs). The authors determined the kinetic parameters of microbial growth and substrate consumption, the biomass productivity, the efficiency of the removal of nitrogen compounds (nitrate and other N compounds) and the lipid productivity. The authors proved that

the use of wastewater in bubble column photobioreactors (PBRs) provided a 58% increase in algal biomass productivity and ammoniacal nitrogen was preferred compared with nitrate during the PBR operation. Concerning lipid production, the authors reported a total lipid content of 0.13 g, i.e. a mass fraction of 12.45%, while the lipid productivity was 17.6 mg/L.d. The authors attributed the low lipid production to the availability of substrate as the limiting step for the growth algal biomass and production of fatty acids.

Taylor *et al.* (2021b) grew cabbage (*Brassica oleracea*) in recirculating hydroponic systems fed with post-anaerobically digested brewery effluent (BE), both with pH adjustment in the range of 6.5–7.0 or unaltered pH (8.0–8.5). The study is interesting from the viewpoint that brewery effluent is not an ideal candidate for its use in hydroponic crop production and there are only a few studies that have reported its land application for growing tomatoes, cabbage and lettuce. The authors were able to ascertain the effect of nutrient solution type and pH on the health, growth and leaf chemical composition of cabbage plants and elucidate the effect of pH on the removal of nutrients and other elements by cabbage plants grown in a hydroponic production system. The hydroponic systems fed with post-primary facultative pond brewery adjusted to pH 6.5 decreased the dissolved inorganic nitrogen, ammonium, phosphate and COD concentrations from 54.8, 36.9, 27.3 and 216 mg/L to 14.9, 0.56, 18.6 and 105 mg/L, respectively. Santos *et al.* (2021) studied the effect of decreasing the hydraulic retention time (HRT) on the stability and efficiency of a novel hybrid anaerobic biofilm baffled reactor (HABBR) treating simulated fat- and salt-rich dairy wastewater. The authors used the treated water for agriculture. During the long-term investigation of 328 days, hydraulic detention times of 72, 24, and 12 h were tested and organic matter removal >90% and biogas in the range of 41–64% was produced in the HABBR. From an application view point, the following recommendations were made by the authors: (i) agricultural reuse of the anaerobic-treated effluent could guarantee yields of the lettuce crops, (ii) 50% dose of dairy anaerobically treated effluent resulted in the best conditions for residue utilization in agriculture, and (iii) a reduction in 50% of the nitrogenous mineral fertilizer can be achieved.

Ozay *et al.* (2021) conducted a series of well-planned experiments to investigate the treatability of plasticizer production industry wastewater using nanofiltration (NF, NF270 and NF90) and reverse osmosis (RO, BW30) membranes. For these two systems, the authors tested the effect of operating pressure, pH of the wastewater, and sequential treatment option on the permeate flux, COD, phthalate, and micropollutant removal efficiencies. Furthermore, the effect of transmembrane pressure and pH of wastewater were tested on the flux and permeate quality. The following important results were reported: (i) the NF270 (NF system) had the highest permeate flux value due to its larger pore size compared with NF90 and BW30 membranes and (ii) COD, phthalate and micropollutant removal efficiency increased with the adjustment of operating conditions for NF90 and NF90 + BW30 membranes. Another study also focused on solving an important industrial wastewater issue arising from the electroplating sectors. Rajasimman *et al.* (2021) tested the removal of zinc ions from wastewater using a novel green emulsion liquid membrane technology. This liquid membrane was prepared using waste cooking oil and a surfactant (SPAN 80), with sulfuric acid as the internal phase. The authors used Box-Behnken Design (BBD) to optimize the operating variables for zinc removal, namely, the external pH, surfactant concentration, internal phase concentration, zinc concentration, external phase to emulsion volume ratio and carrier concentration. To achieve >97% zinc removal, the following optimal conditions were reported: pH - 3.8, surfactant concentration 4% (*v/v*), internal phase concentration – 1.61 N, zinc concentration – 742 mg/L, external phase to emulsion volume ratio - 0.94 and carrier concentration – 8.9%. Sivapragasam *et al.* (2021) tested real-time monitoring as an adaptive strategy towards green treatment of textile effluent using biosorbent prepared from *Acalypha indica*. The authors conducted batch experiments with synthetic and real-time dye effluents under the following optimal conditions: pH = 3.0, dosage of the biosorbent = 1.0 g/L and time = 1 h and achieved the highest adsorption capacity of 6 mg/g and 2 mg/g, respectively. For real-time monitoring, the authors used LabVIEW for the measurement of pH and temperature of the effluent and recommended that there is enormous scope in optimizing the entire process-flow of textile wastewater treatment in order to withdraw, treat and reuse the effluents in a continuous manner. The authors also showed substantial reduction in COD (74%), TDS (20%) and turbidity (53%) due to the application of adsorption technology.

Kan & Duan (2021) highlighted the importance of non-point source (NPS) pollution and suggested a resource-based approach for controlling agricultural NPS pollution using biological agents. According to the authors, in this novel approach, the domestic sewage disposal was carried out under powered or non-powered conditions (i.e. with or without electricity supply), and the domestic organic waste, sewage sludge, and livestock manure were economically utilized to produce biological agents to replace the harmful chemical fertilizers and pesticides that contribute to NPS pollution. The proposed approach was applied in Xichuan County and Xixia County since 2010 and the results have successfully demonstrated its value with

regard to NPS pollution control. From a longevity view point of this approach, the following recommendations were given by the authors: (i) to improve water quality in a sustainable manner, the environmental protection infrastructure in the townships and villages should be improved, and (ii) a corporate and market-oriented operation of rural pollution control should be implemented by involving local stakeholders and the farming communities. Another similar study dealt with the removal of fly ash using a biocatalyst, i.e. *Penicillium chrysogenum,* and ascertained its toxicity effects (Taştan 2021). The author compared two different removal mechanisms, namely, bio-removal and bio-sorption. The results of this study were promising because the highest bio-removal yield was 100% at a fly ash concentration of 0.5%, while the bio-sorption yield was 95% after 24 h of contact time. The author also recommended that fungi are very effective microorganisms for selectively removing heavy metals (i.e. by bio-sorption) from fly ash and reducing their toxicity effects on the environment.

In a study that applied adsorption and biodegradation for removing natural organic matters (NOM), Gong *et al.* (2021) used mesoporous activated carbon MCGL-4 for simultaneous enhancement of adsorption and bio-degradation by multistage depth-activation (MDA) in a pilot-scale bio-enhanced activated carbon (BEAC) system. In that study, in order to determine the synergistic effect between bio-degradation and adsorption, rapid small-scale column tests system (RSSCTs) tests were performed. The adsorption capacities for humic-like organics were 67,725 mg DOC/(kg carbon) and the removal due to biodegradation was 31,674 mg DOC/(kg carbon), respectively. The authors ascertained that the mesopores played an important role for the adsorption of humic-like organics. Jin-xi & Singh (2021) evaluated the performance of a modified flocculant (PEI-T) for the removal of turbidity, heavy metal (Hg^{2+}) and the activator EDC.HCl. The novel PEI-T was prepared under the following conditions: room temperature, nPEI: nTGA = 1:2, PEI concentration = 4%, time t = 12 h, catalyst EDC = 6 mL, and initial pH = 2.5. In this study, the authors deduced the removal mechanism as follows: (i) complexation reaction with Hg^{2+} in the form of coordination bonds and covalent bonds to form a stable insoluble heavy metal complex to precipitate PEIT-Hg, (ii) redox reaction, and (iii) the presence of Na^{2+}, Mg^{2+}, and Ca^{2+} in wastewater promoted the removal of heavy metals by PEI-T. Nandi *et al.* (2021) studied the biodegradation of benzyl butyl phthalate (BBP) and dibutyl phthalate (DBP) by *Arthrobacter* sp. via micellar solubilization in a surfactant-aided system. In systems assisted by the action of surfactants, the bioavailability of hydrophobic organic pollutants is increased either by decreasing the interfacial tension between the aqueous and non-aqueous phases or by the solubilization of hydrophobic organic compounds in the core of the micelles formed by surface-active agents. The authors used four chemical surfactants, e.g. Tween 20, Tween 80, Triton X-100 and sodium dodecyl sulphate (SDS), and assessed their capability to solubilize BBP and DBP in aqueous solutions. Based on a series of batch tests, Tween 80 was found to be highly effective for enhancing the bioavailability of both BBP and DBP and their biodegradation by *Arthrobacter* sp. Zamora *et al.* (2021) compared coriander (*Coriandrum sativum* L.), cv. Verdão yields under fertigation via drip irrigation with a continuous application and in pulse type applications, with 40, 60, 80, 100 and 120% of the crop evapotranspiration (ETc) being recovered. The authors deduced that the frequency of watering and fertilization affected the crop yield, whereas pulse type drip irrigation saves 40% water compared to continuous irrigation. From an application view point, pulsed fertigation was recommended by the authors for coriander crop because it provides higher shoot and root values of fresh and dry mass as well as plant height and yield values, with evapotranspiration replacement of $<100\%$.

Ramasamy *et al.* (2021) highlighted the need for an improved and controlled Smart Energy Distribution Network (SEDN) in industries and used Python-based simulations of weighted least squares (WLS) and principal component analysis (PCA) based Data Reconciliation (DR) techniques on selected flow streams of SEDN. Four important results were reported in that study: (i) the DR technique showed good ability to treat random errors present in flow sensor data used in water distribution networks, (ii) the performance of DR techniques for small and large scale networks using Python-based simulation, (iii) RMSE is the best metric for evaluation because it is very sensitive to small changes in the measurement and estimates, and (iv) when the difference in magnitudes between process variables increases, the PCA-DR combination performs less accurately compared to the WLS-DR. Another study highlighted the importance of applying the most popular Soil Conservation Service Curve Number (SCS-CN) method for calculating storm depth from a rainfall event (Upreti & Ojha 2021). In order to reduce the error in predicting runoff calculations during an unexpected rise in the SCS-CN, the authors considered pre-storm rainfall as an event-based runoff model, and evaluated the relative significance of antecedent precipitation (P5) on the calculated runoff amount. According to the results of this model-based study, the maximum potential retention value (S, mm) changed due to the antecedent 5 days' rainfall values and the authors were able to test the performance of this model using rainfall-runoff events of 114 watersheds located in the USA.

Chen & Wang (2021) applied an inexact multi-stage interval-parameter partial information programming model (IMIPM) for urban water resources planning and management under uncertainties. The authors combined the following optimization techniques: two-stage stochastic programming (TSP), interval-parameter programming (IPP), linear partial information theory (LPI) and multistage stochastic programming (MSP) into one framework and applied it for a real case study in Harbin where the manager had to allocate water from multi-water sources to multi-water users during multi-planning time periods. The developed framework was used to verify the rationality and practicality of this approach by managers in Harbin and helped them to propose multiple decision-making alternatives. Torres *et al.* (2021) formulated a method for classifying the interrelation between sectoral regulatory laws and the 'water-energy-agriculture nexus' concept in Brazil. In that study, the authors identified the level of interrelation between sectoral regulatory laws and the main characteristics present in the nexus concept and determined the main strengths and weaknesses of sectoral regulatory laws upon the nexus concept. The main aspect used from multicriteria analysis was the classification phase of alternatives according to selected multiple criteria and three different steps were used by the authors: I: Definition of the criteria – Main characteristics of the composition of the nexus concept, II: Definition of alternatives – regulatory legislation, and III: Evaluation and classification of the interrelation between criteria and alternatives. The authors recommended that the Brazilian energy sector needs to be tightly integrated with water and agriculture legislations, especially in matters concerning biofuels and biodiesel policies that have a strong association with the growing agricultural sectors.

The Editors of this special issue are confident that the papers published in this issue are from a wide array of multidisciplinary fields, both from the industrial and academic community, and they will certainly attract broad readership from scholars and practising engineers from the environmental, modelling, biochemical and agricultural sectors. Our special thanks to Ms Emma Buckingham, Editorial Operations Manager, IWA Publishing and the entire production team at IWA Publishing for their valuable support in bringing out this issue successfully. We also thank all the reviewers for providing critical reviews, comments and feedback on manuscripts that were submitted for this thematic special issue.

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