Wastewater Management in Arid & Semi-Arid Regions as a Mitigation Measure to Combat Climate Change

Bibliography

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Introduction

Climate change is one of the major challenges of our time that pose unprecedented stress to the environment and threats to human health. The global impacts of climate change are vast, spanning from extreme weather events to changes in patterns and distribution of infectious diseases. Lack of rainfall associated with higher temperatures has a direct influence on agricultural production. This is compounded by a growing population forecasted to expand further with increasing needs for food and water. All this has led to the increasing use of wastewater worldwide. In this review, we more specifically discuss the use of untreated wastewater in agriculture in the Middle East and North Africa (MENA) countries, the most arid region in the world. This presents challenges for agriculture with respect to water availability and increasing wastewater use in agri-food chain. This in turn exerts pressures on the safety of food raised from such irrigated crops. Current practices in the MENA region indicate that ineffective water resource management, lack of water quality policies, and slow-paced wastewater management strategies continue to contribute to a decline in water resources and an increased unplanned use of black and graywater in agriculture. Radical actions are needed in the region to improve water and wastewater management to adapt to these impacts. In this regard, the 2006 WHO guidelines for the use of wastewater contain recommendations for the most effective solutions. They provide a step-by-step guide for series of appropriate health protection measures for microbial reduction targets of 6 log units for viral, bacterial, and protozoan pathogens, but these need to be combined with new varieties of crops that are drought and pest resistant. More research into economic local treatment procedures for wastewater in the region is warranted.

The bibliography highlights some of the latest publications such as: journal articles, book chapters and conference papers which were published in the past four years (2019-2022) and cover the themes of the Conference using NSTIC e-resources: Web of Science & Scopus.

https://www.liebertpub.com/doi/abs/10.1089/fpd.2017.2389

Bibliography

Title: Scalability of microbial electrochemical technologies: Applications and challenges.
Author: Jadhav D.A.a, b,Park S.-G.a,Pandit S.c,Yang E.d,Ali Abdelkareem M.e, f, g,Jang J.-K.i,Chae K.-J.
Source: Bioresource Technology, Volume 345, February 2022

Abstract:
During wastewater treatment, microbial electrochemical technologies (METs) are a promising means for in situ energy harvesting and resource recovery. The primary constraint for such systems is scaling them up from the laboratory to practical applications. Currently, most research (~90%) has been limited to benchtop models because of bioelectrochemical, economic, and engineering design limitations. Field trials, i.e., 1.5 m3 bioelectric toilet, 1000 L microbial electrolysis cell and industrial applications of METs have been conducted, and their results serve as positive indicators of their readiness for practical applications. Multiple startup companies have invested in the pilot-scale demonstrations of METs for industrial effluent treatment. Recently, advances in membrane/electrode modification, understanding of microbe–electrode interaction, and feasibility of electrochemical redox reactions have provided new directions for realizing the practical application. This study reviews the scaling-up challenges, success stories for onsite use, and readiness level of METs for commercialization that is inexpensive and sustainable.

Title: Sustainable saltwater intrusion management in coastal aquifers under climatic changes for humid and hyper-arid regions
Authors: Abd-Elaty I., Straface S. S., Kuriqi A.Kuriqi A.
Source: Ecological Engineering, Volume 171, November 2021

Abstract:
Saltwater Intrusion (SWI) in many coastal areas is accelerated by freshwater boundary changes due to over-pumping and decreasing aquifer recharge and sea-level rise. This study aims to control SWI due to the rise in sea levels in three climate regions: (i) humid and wet regions using storage dams at different heads and recharge ponds, (ii) hyper-arid and arid regions using physical barriers and wastewater treatment aquifer, brackish water abstraction, and desalination (TRAD) method, and (iii) semi-arid and semi-humid regions using a combination of flooding water recharge well-field and cut-off wall. The study was developed using the world benchmark problem of Henry's problem and Biscayne aquifer in the Cutler Ridge area near Deering Estate, Florida, USA. The finite-difference code SEAWAT was used in numerical simulations. The numerical results indicated that increasing the artificial recharge lake capacity minimizes the SWI in humid and wet regions with a high level of flooding. Moreover, the intrusion is mitigated using physical barriers and the TRAD method for hyper-arid and arid regions. Combining physical barriers during dry seasons and recharge wells for wet seasons resulted in suitable measures to managed the SWI in semi-arid and semi-humid regions. Finally, the best strategy to mitigate the SWI and minimize the desalination costs depends on the precipitation rates. Therefore, the methodology applied to this study represents a valuable tool in order to select the best method based on the climate conditions and particularly the precipitation intensity to increase the water budget in freshwater aquifers.

Title: Scenario-based numerical simulation to predict future water quality for developing robust water management plan: a case study from the Hau River, Vietnam

Author: Duc N.H., Avtar R., Avtar R.,Kumar P.,Lan P.P.

Source: Mitigation and Adaptation Strategies for Global ChangeVolume 26, Issue 7October 2021.

Abstract:
Rapid population growth, urbanization, industrialization, and climate change are the key drivers causing serious water pollution around the globe. Considering the impacts of these key drivers, this study employed the Water Evaluation and Planning (WEAP) simulation tool to simulate the future water quality in a nearly 60-km stretch of the Hau River, Vietnam. The business-as-usual (BAU) scenario; scenarios with measures (WM), i.e., wastewater treatment plants (WWTPs) for treating 75% (WM75) and 100% (WM100) of total future wastewater generated; and the optimistic scenario (WM_Opt., i.e., WM100 + additional treatment plants for river water (RWTPs)) to achieve the desired water quality, were applied to simulate the future Hau River water quality for the year 2030. Result suggests that the average values of biochemical oxygen demand (BOD), total coliform (TC), nitrate (NO3−), and phosphate (PO43−) in the wet season of 2030 under BAU scenario will be increased by 16.01%, 40.85%, 30.49%, and 20.22%, respectively, in comparison to those of the current year, i.e., 2018. In the dry season, these rates will be increased by 27.80%, 65.94%, 31.05%, and 20.64%, respectively. Under the scenario with measures (WM75 and WM100), although the Hau River water quality was improved but did not reach the desired limits, especially for BOD and PO43− levels in the downstream region. However, under the WM_Opt. scenario, the average simulated values of both BOD and PO43− will be significantly declined by 76.53% and 63.96%, respectively as compared to the current situation and help to achieve river water quality under class A. This study is providing policy-relevant scientific information, vital for sustainable water resource management.

Title: Collaborative Control Method and Case Study of Greenhouse Gases in Urban Sewage Treatment Plants

Author: Fu J. Fu J. Feng X.,Gao Q.,Ma Z.,Liu Q.,Li Y.,Lü L

Source: Research of Environmental SciencesVolume 34, Issue 9, Pages 2086 – 2093 September 2021

Abstract:
The collaborative control of pollutants and greenhouse gases has been widely recognized. Urban sewage treatment plant is not only the object of strengthening the treatment and management of water environmental pollutants by the ecological and environment department, but also an important sector of greenhouse gas emissions that cause climate change. How to establish the accounting method for the collaborative reduction of pollutants and greenhouse gases in urban sewage treatment plants has great practical significance for improving the benefits of coordinated treatment of pollutants and greenhouse gases and formulating strategic guidelines of collaborative control policies and measures. This paper puts forward the accounting boundary, collaborative mechanism and accounting method of collaborative greenhouse gases in urban sewage treatment plants, and makes an empirical analysis through a case, and gives how to calculate the collaborative control effect and collaborative degree of pollutant removal.

Title: Investigation of groundwater depletion in the state of Qatar and its implication to energy water and food nexus.

Author: Bilal H. Bilal H.,Govindan R. R.,Al-Ansari T
Source: Water (Switzerland) 13, Issue 18September 2021
Abstract:
Groundwater is a precious freshwater resource heavily relied upon by agricultural activities in many parts of the world, and especially by countries with limited water resources located in arid regions. Groundwater resources are under severe pressures due to population increase, urbanisation and socio-economic development, with potential for causing long-term threats to human life and natural ecosystems. This study attempts to investigate the impacts of local and regional climatic trends, and establish key forcing functions that have changed local groundwater resources. The main questions answered through this study include: Are these changes beneficial or detrimental? If they are detrimental, what is the future outlook for impacts on the ecosystem? What are the corrective actions needed to avert the long-term risks in arid environments? In view of this, the methodology developed in this study focuses on a joint time-series statistical analysis using ground data as well as Gravity Recovery and Climate Experiment (GRACE) satellite data. Results show a substantial depletion in the groundwater thickness (0.24 ± 0.20 cm/year) during the period of observation (2002–2020). Long-term temperature data indicates that the annual mean temperature increased significantly by 1.02◦C between 1987 and 2016, while total rainfall exhibited a slight decreasing trend. In addition to groundwater extraction, fluctuations in monthly rainfall, soil moisture, evapotranspi-ration and relative humidity support the groundwater thickness reduction of GRACE datasets. The use of desalinated water and wastewater reuse in the agriculture sector may reduce the pressure on groundwater resources. Optimization, adaptation and mitigation in the EWF nexus will further improve the sustainability of the EWF resources.

Title: The status of freshwater and reused treated wastewater for agricultural irrigation in the Occupied Palestinian Territories.
Author: Salem H.S. Salem H.S.,Yihdego Y.,Hamaaziz Muhammed H.
Source: Journal of Water and Health, Volume 19, Issue 1, Pages 120–158, 1 February 2021

Abstract:
Global freshwater scarcity is imposing the demand for using non-conventional water resources for irrigation and non-irrigation purposes. Direct reuse of treated wastewater for agricultural irrigation is a widespread practice in arid and semi-arid regions, because of water shortage and scarcity. Water scarcity and the need for ecological sustainability have led to the introduction of treated wastewater as an additional water resource in the national water resources' management plans of Mediterranean countries. The use of wastewater for irrigation is an important tool for water resources' supplement. However, the reuse of effluent in irrigation can have negative impacts on crop quality and soil conditions, as well as on public health and the environment. Furthermore, inappropriate management of agricultural irrigation with treated wastewater can also pose problems for plant production and the physical and chemical properties of soils. This paper presents some approaches to understand the impacts of reusing treated wastewater. It also presents a critical analysis of the treated wastewater's reuse for irrigation in the Occupied Palestinian Territories (OPT), while shedding light on the water status in the OPT. The paper investigates the wastewater treatment and reuse for agricultural irrigation, especially in the lack of control of Palestinians on their own freshwater resources in the OPT.

Title: Groundwater economics in arid regions: Abu Dhabi emirate case study
Authors: Dawoud M.A
Source: Desalination and Water Treatment, Volume 176, Pages 84 – 93 February 2020
Abstract:
In arid and semiarid regions, groundwater is scarce, limited and non-renewable but it is a vital resource that supports a variety of societal uses and benefits. With growing demand due to exten-sion in agriculture and domestic sectors, groundwater resources are coming under greater pressure following reductions in surface water yields, due to reduced rainfall and over abstraction. Over abstraction due to increasing demand or climate, change-driven changes in spatial distribution of precipitation can result in a reduction in groundwater quantity and deterioration in quality. Increased population and economic development inevitably result in an increase in the generation of waste products and, if disposed of inappropriately, these have the potential to contaminate groundwater resources and lead to degradation and economic costs. This creates the need for a higher profile regu-latory and management regime for this limited groundwater resources. Given climate variability and the environmental challenges, the importance of groundwater as a resource is ever increasing in arid regions. Abu Dhabi emirate is an arid region facing the challenges of renewable fresh water scarcity. In the year 2014, groundwater use accounts for about 63% of total water demand in the Emirate, with the remaining portion of demand being met through desalinated (28%) and recycled water (9%). Groundwater is used mainly for agriculture, forestry sectors, which together have accounted for over 95% of total annual withdrawals. Agriculture alone has accounted for 80% of total recent withdrawals. The total present annual abstraction from the groundwater aquifers is about 2,300 million cubic meters. However, the annual natural recharge to the aquifer systems ranges between 90 and 140 million cubic meters only. Numerous wellfields abstract groundwater of various qualities and in some areas massive over-abstraction has resulted in alarming groundwater declines and a severe deterioration in groundwater quality. This policy has led to a reduction in the groundwater table which caused numerous shallow wells to go dry and impact the farms. It is estimated that there is still 641 km³ groundwater resources available (saline, brackish and fresh), but only less than 3% of this reserve is fresh and, based on current abstraction rates, both fresh and brackish reserves will be depleted within the next 50 years. The purpose of this study is to assess the economic value of groundwater resources in the Abu Dhabi Emirate. A dynamic hydro-economic optimization model was developed and applied.

Title: Farmers' attitude towards using treated wastewater for irrigation: The question of sustainability.

Author: Khanpae M. Khanpae M.,Karami E. Karami E.,Maleksaeidi H. aleksaeidi H.,Keshavarz M.c Keshavarz M.

Source: Journal of Cleaner Production, Volume 24310 January 2020
Abstract:
In the context of climate variability and change, application of treated wastewater for irrigation is an appropriate approach to cope with the water scarcity in arid and semi-arid regions. Farmers will adopt treated wastewater if they perceive it as an economically beneficial, socially acceptable, environmentally sound, and have little or no health risks. However, few studies have investigated the sustainability of wastewater irrigated farms. Also, almost all the studies have focused only on the farmers' attitude or field observation data, which can underestimate the wastewater impacts on the agricultural sustainability. Therefore, the aim of this study was to investigate farmers' attitude towards economic, social, environmental and health sustainability of wastewater irrigated farms. To prevent misleading,

the economic and environmental impacts of wastewater were validated with real field observations. A survey of 197 wastewater and freshwater users of Marvdasht County, Iran, selected through a systematic random sampling method indicated that wastewater users had more positive attitude towards the economic, social and environmental sustainability of wastewater irrigated agriculture. However, field data analysis did not support the farmer's optimistic views and revealed that long-term application of wastewater could intensify the concentration of heavy metals in the soil and water, reduce the quality of soil, plant and water and also threat the farmers and consumer's health. This implies that sustainable implementation of wastewater use projects depends on the psychological support of the farmers and consideration of real impacts of the wastewater resources on the human and environment. Some recommendations are offered to improve sustainable wastewater management.

Title: Prediction of odor complaints at a large composite reservoir in a highly urbanized area: A machine learning approach

Authors: Mulrow J.a, Mulrow J.K shetry N. Brose D.A. Kumar K.d,Jain D. ,Shah M., Kunetz T.E. Varshney L.R.

Source: Water Environment Research, Volume 92, Issue 3, Pages 418 - 4291 March 2020

Abstract:
Odorous compound emissions and odor complaints from the public are rising concerns for agricultural, industrial, and water resource recovery facilities (WRRFs) near urban areas. Many facilities are deploying sensors that measure malodorous compounds and other factors related to odor creation and dispersion. Focusing on the Metropolitan Water Reclamation District of Greater Chicago's (MWRDGCs) Thornton Composite Reservoir (7.9 billion gallon capacity), we used meteorological, operational, and H2S sensor data to train a 3-day advance-warning predictor of local odor complaints, so as to implement targeted odor prevention measures. Using a machine learning approach, we bypassed difficulties in modeling both physical dispersion and human perception of odors. Utilizing random forest algorithms with varied settings and input attributes, we find that a small network of H2S sensors, meteorological data, and operational data are able to predict odor complaints three days in advance with greater than 60% accuracy and less than 25% false-positive rates, exceeding MWRDGC’s standards required for full-scale deployment. Practitioner points: A random forest algorithm trained on H2S, weather, and operations data successfully predicted odor complaints surrounding a large composite reservoir. Thirty-two data attribute combinations were tested. It was found that H2S sensor data alone are insufficient for predicting odor complaints. The best predictor was a Random Forest Classifier trained on weather, operational, and H2S readings from the reservoir corner locations. This study demonstrates odor complaint prediction capability utilizing a limited set of data sources and open-source machine learning techniques. Given a small network of H2S sensors and organized data management, WRRFs and similar facilities can conduct advance-warning odor complaint prediction.

Title: Mainstream ammonium recovery to advance sustainable urban wastewater management**.**

Authors: Cruz H.a,Law Y.Y. Guest J.S. Rabaey K. Batstone D. Laycock B. Verstraete W. Verstraete W.,Pikaar I.

Source: Environmental Science and Technology, Volume 53, Issue 191 October 2019

Abstract:
Throughout the 20th century, the prevailing approach toward nitrogen management in municipal wastewater treatment was to remove ammonium by transforming it into dinitrogen (N2) using biological processes such as conventional activated sludge. While this has been a very successful strategy for safeguarding human health and protecting aquatic ecosystems, the conversion of ammonium into its elemental form is incompatible with the developing circular economy of the 21st century. Equally important, the activated sludge process and other emerging ammonium removal pathways have several environmental and technological limitations. Here, we assess that the theoretical energy embedded in ammonium in domestic wastewater represents roughly 38-48% of the embedded chemical energy available in the whole of the discharged bodily waste. The current routes for ammonium removal not only neglect the energy embedded in ammonium, but they can also produce N2O, a very strong greenhouse gas, with such emissions comprising the equivalent of 14-26% of the overall carbon footprint of wastewater treatment plants. N2O emissions often exceed the carbon emissions related to the electricity consumption for the process requirements of WWTPs. Considering these limitations, there is a need to develop alternative ammonium management approaches that center around recovery of ammonium from domestic wastewater rather than deal with its "destruction" into elemental dinitrogen. Current ammonium recovery techniques are applicable only at orders of magnitude above domestic wastewater strength, and so new techniques based on physicochemical adsorption are of particular interest. A new pathway is proposed that allows for mainstream ammonium recovery from wastewater based on physicochemical adsorption through development of polymer-based adsorbents. Provided adequate adsorbents corresponding to characteristics outlined in this paper are designed and brought to industrial production, this adsorption-based approach opens perspectives for mainstream continuous adsorption coupled with side-stream recovery of ammonium with minimal chemical requirements. This proposed pathway can bring forward an effective resource-oriented approach to upgrade the fate of ammonium in urban water management without generating hidden externalized environmental costs.

Title: Integrated Life Cycle Assessment and Life Cycle Cost Assessment based fuzzy multi-criteria decision-making approach for selection of appropriate wastewater treatment system.
Author: Dewalkar S.V. Shastri S.S.
Source: Journal of Water Process Engineering, Volume 45, February 2022

Abstract:
The current study proposes a comprehensive fuzzy formulated Multi-Criteria Decision Making (MCDM) framework with integrated Life Cycle Assessment (LCA) and Life Cycle Cost Assessment (LCCA) approach for selection of best suitable wastewater treatment (WWT) system, especially for multi-storeyed residential buildings. By utilising a thorough literature survey, experts' opinions and questionnaires, the study attempts to identify four dimensions of sustainability with associated key nineteen indicators. Furthermore, the study is benefited by undertaking quantitative parameters related to environmental and economic sustainability assessed by LCA and LCCA respectively. The proposed three-phase methodological framework illustrates the identification of widely used WWT systems in the first phase followed by Fuzzy Analytic Hierarchy Process (FAHP) assessment for criteria and indicators' screening and finalisation in the second phase and ranking of alternative by Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) in the third phase. Moreover, the current paper suggests a novel approach of incorporating “environmental floor” in multi-storeyed building, where gravity governed nature-based

wastewater treatment tanks of Decentralized On-Site Integrated WAste Management (DOSIWAM) system can be positioned. To test the proposed framework, the sustainability of DOSIWAM system is compared with five widely used wastewater treatment systems viz. membrane bioreactor (MBR), moving bed biofilm reactor (MBBR), sequencing batch reactors (SBR), activated sludge process (ASP), soil biotechnology (SBT). Results of alternative ranking indicate DOSIWAM (allocated at environmental floors) as the best suitable option followed by the second, third and fourth rank of MBR, SBT and SBR respectively whereas, MBBR and ASP are the least preferred. It has been observed that the experts prefer mostly natural treatment systems since they are more sustainable in environmental and economic considerations. In addition, by changing the weights of the main criteria, sensitivity analysis is carried out considering five scenarios, which signifies in three out of five scenarios; relative percentage change in criteria weight does not affect the first rank of the DOSIWAM system. The developed framework successfully facilitates a reliable base for the selection of the best suitable WWT system for multi-storeyed residential building and could be made available to the relevant local planning authority to incentivize the effort undertaken for the welfare of citizens as well as the government.

Title: What's the cost-effective pattern for rural wastewater treatment?
Author: Huang Y. Wu L., Li P., Li N., He Y.
Source: Journal of Environmental Management, Volume 3031 February 2022

Abstract:
Inadequate sanitation infrastructure is a global problem that is particularly impacting rural areas. And decentralized wastewater management system is considered as the feasible solution for rural sewage treatment (RuST). However, determining the cost-effective (CE) pattern for decentralized RuST is methodologically challenging because of scarce decision-support tools. In this research, a RuST optimization model (RuST-OM) was developed to gain an insight into the CE pattern of RuST based on the greedy algorithm. This model involves tradeoffs in the economy-of-scale and technology of wastewater treatment system versus the cost and energy consumption of the sewage collection system. The investment associated with the CE pattern for RuST is closely linked to the environmental demand, RuST coverage, topographic complexity, and degree of household dispersion. The cost of the CE pattern falls between the onsite-B and community-based pattern, and this range represents the optimized interval for RuST planning. Nature-based technology is a sustainable alternative for RuST in areas characterized by low or moderate environmental demand. To ensure applicability of the RuST-OM in other countries/regions, built-in datasets (e.g., technology and pipeline design parameters) are designed based on rural area features that can be modified as necessary. This research highlights the utility of the CE pattern for RuST planning, and can serve as a reference for RuST planning around the world.

Title: Self-sustained ultrafiltration coupling vermifiltration for decentralized domestic wastewater treatment: Microbial community and mechanism.
Author: Wang J., Tang X., Liu Y., Xie B., Li G., Liang H.
Source: Resources, Conservation and Recycling, Volume 177, February 2022

Abstract:
In this study, self-sustained ultrafiltration (SUF) without extra backwashing, aeration and chemical cleanings was investigated. To further improve removal performance and membrane permeability, vermifiltration (VF) was introduced, developing VF/SUF (VF

coupling SUF without reflux) and RVF/SUF (VF coupling SUF with reflux). Synergism effects of contaminants removals were achieved with effective removals of dissolved pollutants (e.g., 95.97% of TOC and 45.25% of NH3−N) via VF process, simultaneously with efficient rejections of particles, bacteria, protozoa and metazoan via SUF process, ensuring permeate safety. Notably, vermifilters improved the membrane flux by over 101% relative to the control, attributing to the synergetic effects among the modified bio-fouling layer structure by more prosperous eukaryotic communities, the reduction of extracellular polymeric substances and the increase of inorganics contents. With the usage of reflux, the membrane flux was further elevated by 181% since the reflux delivered more eukaryotes into SUF to increase the heterogeneity of the bio-fouling layer.

Title: Performance evaluation of the integrated hydroponics-microbial electrochemical technology (iHydroMET) for decentralized domestic wastewater treatment.
Author: Yadav R.K., Sahoo S., Patil S.A.
Source: Chemosphere, Volume 288, February 2022.

Abstract:
Here we report on the performance of the integrated drip hydroponics-microbial electrochemical technology (iHydroMET) for decentralized management of domestic wastewater at the household level. The study focused on optimizing the iHydroMET reactor components, followed by its performance evaluation for domestic wastewater treatment at different feed volumes. Based on the reactor components optimization work, granular activated charcoal:cocopeat (20:80) combination for bed matrix, 75% immersed cathode in effluent configuration, and Catharanthus roseus plant were selected for further experiments. The iHydroMET system with the optimized reactor components achieved efficient removal of organic matter (up to 93%) and turbidity (up to 98%) but minimal total nitrogen (<24%) and total phosphorous ([removed]95% efficiency. The UV-treated effluent (<2 MPN/100 mL) with considerable concentrations of N (~34 mg/L) and P (~5 mg/L) nutrients qualifies the standards for agricultural use and landscape irrigation purposes and contribute to lowering the burden on freshwater usage. The system also produced a power density of 30.3 mW/m2. Cultivation of evergreen C. roseus, a high aesthetic value ornamental and medicinal plant, further adds to ecological and environmental benefits of the iHydroMET technology. Further modifications in system operation like creating a saturation zone in the reactor units might improve the electric output and result in sufficient removal of nutrients, making the use of effluent for flushing and other purposes possible in households.

Title: Field-scale decentralized domestic wastewater treatment system: Effect of dynamic loading conditions on the removal of organic carbon and nitrogen.
Authors: Munavalli G.R, Sonavane P. G., Koli M. M., Dhamangaokar B.S.
Source: Journal of Environmental Management, Volume 302, 15 January 2022

Abstract:
The field–scale decentralized wastewater treatment system (DWTS) was developed with an anaerobic baffled reactor (ABR) and a newly configured hybrid constructed wetland (HCW) vegetated with Typha angustifolia and Canna indica to treat 42 kLd of domestic wastewater. Biorack baffled constructed wetland (BBCW) and baffled vertical flow constructed wetland (BVFCW) were used in the first and second stage of HCW respectively. DWTS was assessed for its efficiency to remove COD, BOD and TKN under high (varying flow and varying

COD) and moderate (constant flow and varying COD) dynamic loading conditions. The tracer study and pertinent computation showed the good performance of DWTS in its hydraulic efficiency. COD of raw wastewater was the treatment-limiting step in ABR. BBCW sustained larger fluctuations in loading rates [hydraulic (0.43–10.29 m3/m2.d) and organic (0.08–2.30 kgCOD/m2.d)]. The draining (unsaturated) conditions enhanced COD and BOD removal in BVFCW. DWTS was found to be efficient for the average removal of COD (70–90%) and TKN (40–65%). HCW contributed 50–60% and 70–80% to COD and TKN removal respectively. The quantification of impacts on treatment efficiency and sustainability of DWTS was demonstrated at field-scale under high and moderate dynamic conditions.

Title: Chemical and biological tracking in decentralized sanitation systems: The case of artificial constructed wetlands**.**
Authors: Dailianis S, Charalampous N. Giokas S. lastos D. fthimiou I.Dormousoglou M. Cocilovo C. Faggio C. Shehu A.Shehu J. Lyberatos G.f, Ntaikou I.
Source: Journal of Environmental Management, Volume 300, 15 December 2021

Abstract:
Given that the social and economic sustainability of rural areas is highly based on the protection of natural resources, biodiversity and human health, simple-operated and cost-effective wastewater treatment systems, like artificial constructed wetlands (CWs), are widely proposed for minimizing the environmental and human impact of both water and soil pollution. Considering that the optimization of wastewater treatment processes is vital for the reduction of effluents toxic potential, there is imperative need to establish appropriate management strategies for ensuring CW performance and operational efficiency. To this end, the present study aimed to assess the operational efficiency of a horizontal free water surface CW (HFWS-CW) located in a world heritage area of Western Greece, via a twelve-month duration Toxicity Identification Evaluation (TIE)-like approach, including both chemical and biological tracking tools. Conventional chemical tracking, by means of pH, conductivity, total COD, and nitrogen-derived components, like nitrates and ammonia–nitrogen, were monthly recorded in both influents and effluents to monitor whether water quality standards are maintained, and to assess potent CW operational deficiencies occurring over time. In parallel, Whole Effluent Toxicity (WET) bioassays were thoroughly applied, using freshwater algae and higher plant species (producers), crustaceans and rotifers (consumers), as well as human lymphocytes (in terms of Cytokinesis Block Micronucleus assay) to evaluate the acute and short-term toxic and hazardous potential of both influents and effluents. The integrated analysis of abiotic (physicochemical parameters) and biotic (toxic endpoints) parameters, as well as the existence of "cause-effect" interrelations among them, revealed that CW operational deficiencies, mainly based on poorly removal rates, could undermine the risk posed by treated sewage. Those findings reinforce the usage of WET testing, thus giving rise to the importance of applying appropriate water management strategies and optimization actions, like oxygen enrichment of surface and bottom of HFWS-CW basins, expansion of the available land, the enhancement of bed depth and seasonal harvesting of plants, for ensuring sewage quality, in favor of water resources protection and sustainable growth in rural areas.

Title: Enhancing the method of decentralized multi-purpose reuse of wastewater in urban area.
Authors: Ghafoori S., Hassanpour Darvishi H., Mohamadvali Samani H., Taherei Ghazvinei P.

Source: Sustainability (Switzerland), Volume 13, Issue 24December-2 2021

Abstract:
The reuse of treated wastewater is attractive as a communal source of excess water source in water-scarce counties and nations. The expansion of the urban population and the increase in the coverage of water supply networks and sewage networks will raise the amount of municipal sewage. This can turn into a new-fangled water resource. In the current research, the new campus city was selected as the first case study to design a wastewater reuse and recycling system. Accordingly, one of the most important innovations in the proposed research is the unique applied dimensions, in addition to its first-time performance, and the application of the Geo-land method in wastewater recycling as the theoretical dimension of the design. Clustering the decentralized reuse of wastewater for urban areas showed that significant parts of residential areas are located in the first high priority group. Urban planners can consider the results in establishing a comprehensive plan to prioritize the decentralized use of wastewater in the urban area.

Title: A novel approach to baseline water quality assessment at local and catchment scale: a case study from Berambadi, India
Authors: Raj A.V. Jamwal P., Anju A.K. Kumar P. Biswas D. Rao L. Helliwell R. Richards S. Ellis R. Koseoglu N. Yeluripati J. Connelly S.
Source: Environmental Monitoring and Assessment, Volume 193, Issue 12December 2021

Abstract:
Optimal design and maintenance are necessary for the sustainability of wastewater treatment systems. In this study, we present the outcome of a novel approach to baseline assessment conducted prior to the design and deployment of a decentralized wastewater treatment system at a school in rural India. The baseline water quality monitoring protocol was deployed to assess (a) the quality and quantity of wastewater (greywater and blackwater) flows from the school and (b) the status of surface water and groundwater quality in the catchment. Hourly greywater flows and water quality trends were monitored across four seasons at the school. Average freshwater consumption at the school was 518 ± 322 L/day for hand washing and 287 ± 97 L/day for cooking meals. Greywater generation showed high hourly variations in COD levels. Greywater generated from hand wash and kitchen sources contributed to 110 g/day and 96 g/day of BOD5 respectively and 214 g/day and 141 g/day of COD respectively. Based on additional data from a self-reporting sanitation survey, the organic contaminant load generated from the toilet was estimated to be 1.5 ± 0.1 kg COD/day. At the catchment scale, both groundwater and surface water quality were monitored seasonally to assess the impact of raw sewage and stormwater inputs. Compared with borewells, high nitrate–N levels (> 10 mg/L) were observed in the village hand pump samples throughout the year. Maximum nitrate–N (16 mg/L) and fecal coliforms (3.9 log MPN/100 mL) levels were observed in surface waters during monsoons, indicating the impact of sewage and surface runoff on water quality. The proposed approach is useful to estimate data on freshwater use and wastewater generation at the school and hence to make the case for, and design of, a sustainable water management intervention.

Title: The role of climate change and decentralization in urban water services: A dynamic energy-water nexus analysis.
Authors: Khalkhali M. Dilkina B. Mo W.

Source: Water Research, Volume 2071, December 2021

Abstract:
Urban water services, including drinking water supply and wastewater treatment, are highly energy dependent, contributing to the challenges described under the water-energy nexus. Both future climate change and decentralized water system adoptions can potentially influence the energy use of the urban water services. However, the trend and the extent of such influences have not been well understood. In this study, a modeling framework was developed to quantify both the separate and the combined influences of climate change and decentralization on the life cycle energy use of the urban water cycle, using the City of Boston, MA as a testbed. Two types of household decentralized systems were considered, the greywater recycling (GWR) systems and the rainwater harvesting (RWH) systems. This modeling framework integrates empirical models based on multilinear regression analysis, hydrologic modeling, water balance models, and life cycle assessment to capture the complex interactions among centralized water services, decentralized water system adoptions, and climate parameters for cumulative energy demand (CED) assessment, considering all residential buildings in Boston. It was found that climate change alone will slightly increase the energy use of the centralized systems towards the end of the century, due to the cancelation effect amongst changes in water quality, flow rate, and space and water heating demand. When decentralization is considered alone, we found economically viable decentralized systems may not necessarily produce energy savings. In fact, RWH adoptions may increase energy use. When climate change and decentralization are combined, they will increase the water yield and cost savings of the decentralized systems, while reducing the energy use from the centralized systems. When the centralized systems are further added into the picture, the CED of the entire urban water cycle is projected to increase by 0.9% or 2.3% towards the end of the century under climate change if GWR or RWH systems are adopted by respective cost saving positive buildings.

Title: Miniature microbial fuel cells integrated with triggered power management systems to power wastewater sensors in an uninterrupted mode**.**
Authors: Fan Y. Qian F. Huang Y. Sifat I. Zhang C. Depasquale A.Wang, Li B.
Source: Applied Energy, Volume 302, 15 November 2021

Abstract:
Uninterrupted energy harvest is critical for self-sustained wastewater monitoring in order to achieve efficient and resilient operation of decentralized onsite wastewater treatment facilities. To address this long-standing challenge, an integrated power entity consisting of a miniature microbial fuel cell (volume: 1.5 mL) and a triggered power management system was developed in this study to power the potentiometric millimeter-sized solid-state water sensors for real-time in situ monitoring and uninterrupted transmission of sensor readings (indicating ammonium concentration) under both ammonium shock and toxic shock in wastewater. Specifically, a data trigger including two capacitors, an operation amplifier and a low-power comparator is equipped in the power management system as a switch for turning on power discharge for data transmission once the ammonium shock is captured by the potentiometric sensors, enabling a sufficient recharge duration to store the power needed for high frequency data transmission (16.23 times/min) required under shocks. Furthermore, this power-sensor entity possesses a unique dual-screening capability of capturing the ammonium and toxic shocks, providing an early warning for swift decision making, reducing ~17% of ammonium discharge and saving ~42% of energy consumption in decentralized onsite wastewater treatment facilities.

Title: Life cycle assessment of greywater treatment systems for water-reuse management in rural areas.
Authors: Rodríguez C., Sánchez R., Rebolledo N. Schneider N. Serrano J., Leiva E.
Source: Science of the Total Environment, Volume 795, 15 November 2021

Abstract:
Water scarcity is a major concern worldwide. Population growth, as well as the intensive use of water resources for industrial and agricultural activities, among others, have caused water stress in various regions of the world. Rural areas are usually more affected due to water scarcity and a lack of sanitary infrastructure. The current practices associated with urban water management have been considered inefficient to respond to these problems. In recent years, the reuse of greywater has emerged as a promising and sustainable alternative. Several pilot greywater treatment systems have been implemented in rural areas of different countries, however, studies about the environmental impacts of these decentralized systems under different scenarios are lacking. In this work, the life cycle assessment of greywater treatment systems considering several scenarios was studied. Our results showed that the decrease in environmental impacts due to the saving of drinking water is more evident when the water supply is carried out through cistern trucks. This occurs because the environmental impact of land transport of water is extremely high and represents over 89% of the global warming indicator [kg CO2 eq] and 96% ozone depletion [kg CFC-11 eq] contributions of the system. Greywater treatment systems with backwashing and solar panels as a source of energy have lower environmental impacts, reducing CO2 and CFC emissions by 50% for the maintenance phase and by 85% (CO2) and 47% (CFC) for the operation phase. Furthermore, the acquisition of solar panels was economically feasible, with a payback of 19.7 years. This analysis showed the environmental feasibility of small-scale greywater treatment systems in rural areas affected by water scarcity. Furthermore, the proposed approach has contributed to understand the impact of greywater treatment systems in rural areas, which could become a support tool to integrate greywater reuse practices in different communities.

Title: Evaluating urban wastewater remediation efficiency of the Hydroponic Vetiver System through predictive modelling using Artificial Neural Network
Authors: Ghosh K. Sarkar A.
Source: Environmental Technology and Innovation, Volume 24November 2021

Abstract:
Urban wastewater management requires alternative cost-efficient, energy-efficient sustainable technologies as conventional electro-mechanical engineering systems are unable to keep pace with the wastewater infrastructure requirements of the rapidly urbanizing world, especially in developing countries. Sustainable urban wastewater management remains a distant goal as none of the existing systems address the treatment of the urban water bodies, which are the last mile of the urban wastewater journey. Literature review shows that among the various potential decentralized solutions, the Hydroponic Vetiver system (HVS) shows good performance in remediation of different types of wastewater. The paper aims to evaluate the general quantitative wastewater remediation potential of the HVS by formulating a predictive model using Artificial Neural Network (ANN). The water quality parameters (WQP) under discussion are Biochemical oxygen demand (BOD) and Chemical oxygen demand (COD). The four significant predictor variables of inlet concentration, plant density, hydraulic retention time, and pH value were analysed from secondary sources of laboratory

experiments conducted worldwide. The trained, tested, and validated neural network models for BOD and COD showed high predictive accuracy and goodness-of-fit. The HVS predictive model will enable municipal policymakers, urban planners, and water managers to measure the wastewater remediation potential of any given urban water body

Title: Environmental Concern Priming and Social Acceptance of Sustainable Technologies: The Case of Decentralized Wastewater Treatment Systems
Authors: Gómez-Román C. Sabucedo J.-M., Alzate M. Medina B.
Source: Frontiers in Psychology, Volume 12, 16 September 2021

Abstract:
According to a report by the World Economic Forum, the water crisis is the fourth most serious global risk to society. The apparent limitations of the hydraulic paradigm to solving this crisis are leading to a change in water management approaches. Recently, decentralized wastewater treatment systems have re-emerged as a partial solution to this problem. However, to implement these systems successfully, it is necessary not only to design this technology but also to have social support and willingness among citizens to use it. Previous studies have shown that these technologies are often perceived as being too costly, and people often do not consider the need for adopting them. However, it has also been pointed out that thinking about these technologies as a sustainable endeavor to reduce human impact on the environment can help to overcome the barriers to usage. Thus, we test whether priming environmental concerns before presenting information about decentralized wastewater treatment plants will increase acceptance of those technologies. In this study, we test whether priming environmental concerns can enhance the acceptance of decentralized wastewater treatment plants even when presenting disadvantages of the technology. In order to do so, we designed an experimental study with a sample of 287 people (85.7% women, Mage=20, 28). The experimental design was 2 (priming the environmental concern vs. no priming)×2 (type of information: only advantages vs. advantages and disadvantages). The results showed that those in the environmental concern priming condition had more positive attitudes and behavioral intentions toward decentralized wastewater treatment plants than those in the control condition group. Participants who received only advantages information had a more positive perception toward the decentralized wastewater systems than in the condition, where disadvantages were present, but in the priming condition this difference was not significant. This implies that priming environmental concern helps to overcome the possible disadvantages that act as barriers to acceptance.

Title: Decentralized management of sewage using septic tanks and anaerobic filters and its potential to comply with required standards in a developing country: a case study in Brazil
Authors: Rodrigues Mesquita T.C. Pereira Rosa A., Oliveira Santos T.F. Carraro Borges A. Calijuri M.L. de Paula Souza F.M.
Source: Environmental Science and Pollution Research, Volume 28, Issue 36, Pages 50001 – 50016, September 2021

Abstract:
To investigate the feasibility of implementing decentralized sewage treatment systems aiming to meet environmental standards, the performance of three decentralized wastewater treatment plants (WWTPs) comprising septic tanks and anaerobic filters (ST+AF) was evaluated. The ability of the WWTPs to comply with the provisions of the legislation and the

technical literature was investigated by monitoring physical and chemical parameters at the entrance and exit of the WWTPs, from May 2017 to August 2018. Considering that factors such as operational routine, design of treatment systems, and the existence of pluvial contributions to the sewage network can influence the performance of WWTPs, an investigation of these factors was conducted. The results show that the ST+AF systems can meet the requirements of the legislation. The hypothesis raised in this study is that factors such as cleaning routine and dimensioning of the treatment units can influence the performance of the systems. The best performance was found in the WWTP submitted to frequent cleaning and whose ST dimensions were closest to those recommended by technical standards. The average annual efficiencies of removal of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in this WWTP assumed values of 93 and 89%, while its solid effluents presented concentrations 82% below the limit established in legislation. Finally, no rainwater contributions were found in the WWTPs, which may be associated with the use of short collection networks in decentralized systems.

Title: Secondary transmission of SARS-CoV-2 through wastewater: Concerns and tactics for treatment to effectively control the pandemic

Authors: Thakur A.K., Sathyamurthy R., Velraj R. Lynch I. Saidur R. Pandey A.K. Sharshir S.W. Kabeel A.E. Hwang J.-Y. Ganesh Kumar P.

Source: Journal of Environmental Management, Volume 29015 July 2021

Abstract:
The SARS-CoV-2 virus has spread globally and has severely impacted public health and the economy. Hand hygiene, social distancing, and the usage of personal protective equipment are considered the most vital tools in controlling the primary transmission of the virus. Converging evidence indicated the presence of SARS-CoV-2 in wastewater and its persistence over several days, which may create secondary transmission of the virus via waterborne and wastewater pathways. Although, researchers have started focusing on this mode of virus transmission, limited knowledge and societal unawareness of the transmission through wastewater may lead to significant increases in the number of positive cases. To emphasize the severe issue of virus transmission through wastewater and create societal awareness, we present a state of the art critical review on transmission of SARS-CoV-2 in wastewater and the potential remedial strategies to effectively control the viral spread and safeguard society. For low-income countries with high population densities, it is suggested to identify the virus in large scale municipal wastewater plants before following up with one-to-one testing for effective control of the secondary transmission. Ultrafiltration is an effective method for wastewater treatment and usually more than 4 logs of virus removal are achieved while safeguarding good protein permeability. Decentralized wastewater treatment facilities using solar-assisted disinfestation methods are most economical and can be effectively used in hospitals, isolation wards, and medical centers for reducing the risk of transmission from high local concentration sites, especially in tropical countries with abundant solar energy. Disinfection with chlorine, sodium hypochlorite, benzalkonium chloride, and peracetic acid have shown potential in terms of virucidal properties. Biological wastewater treatment using micro-algae will be highly effective in removal of virus and can be incorporated into membrane bio-reaction to achieve excellent virus removal rate. Though promising results have been shown by initial research for inactivation of SARS-CoV-2 in wastewater using physical, chemical and biological based treatment methods, there is a pressing need for extensive investigation of COVID-19 specific disinfectants with appropriate concentrations, their environmental implications, and regular monitoring of transmission. Effective

wastewater treatment methods with high virus removal capacity and low treatment costs should be selected to control the virus spread and safeguard society from this deadly virus.

Title: Sustainable stormwater management under the impact of climate change and urban densification
Authors: Rosenberger L.,Leandro J. Pauleit S. Erlwein S.
Source: Journal of Hydrology, Volume 596, May 2021

Abstract:
The demand for living space is rising in growing cities. To restrict urban expansion in the outskirts, a common strategy is to densify existing neighbourhoods. Densification implies the increase of water impervious area which increases the vulnerability to flooding during extreme precipitation events. Sustainable urban drainage systems are considered as a strategy to handle stormwater runoff locally and thus relieve the sewage system. This study investigates the combined quantitative hydrological impact of densification and sustainable stormwater management measures in a residential neighbourhood in Munich, Germany. The living-lab approach pursues the application of nature-based solutions in a real planning case to achieve positive climate effects while densifying the neighbourhood. The study is based on single event simulations of three return periods with the physically based software PCSWMM. The events are implemented for both current and climate change precipitation intensities of the RCP 8.5 projection for 2040–2069. Three scenarios are implemented: a status quo, a business as usual scenario (additional buildings without compensation measures) and a best-case scenario (one additional floor with green roofs disconnected from the sewers in combination with rain gardens and porous pavements on the land parcels). The comparison between the different scenarios focuses on three main aspects of the water balance, namely, infiltration, runoff and storage. The results show that measures for sustainable stormwater management are crucial elements to cope with an increasing number of heavy precipitation events due to climate change. The best-case scenario significantly outperforms the other two concerning water infiltration, surface runoff and storage. Most notably is the impact of climate change projection rainfall intensities for 2040–2069. The outcomes for these intensities clearly show the positive impact of sustainable water-sensitive design. The results demonstrate that it is in fact possible to enhance the water balance and gain new living space simultaneously if a sustainable urban planning strategy is implemented that includes future-oriented stormwater management.

Title: Evaluation of multiple analytical methods for SARS-CoV-2 surveillance in wastewater samples.
Authors: Kaya D., Niemeier D. Ahmed W. Kjellerup
Source: Science of the Total Environment, Volume 808, 20 February 2022

Abstract:
In this study, 14 virus concentration protocols based on centrifugation, filtration, polyethylene glycol (PEG) precipitation and ultrafiltration were tested for their efficacy for the quantification of SARS-CoV-2 in wastewater samples. These protocols were paired with four RNA extraction procedures resulting in a combination of 50 unique approaches. Bovine respiratory syncytial virus (BRSV) was used as a process control and seeded in each wastewater sample subjected to all 50 protocols. The recovery of BRSV obtained through the application of 50 unique approaches ranged from <0.03 to 64.7% (±1.6%). Combination of centrifugation as the solid removal step, ultrafiltration (Amicon-UF-15; 100 kDa cut-off;

protocol 9) as the primary virus concentration method, and Zymo Quick-RNA extraction kit provided the highest BRSV recovery (64.7 ± 1.6%). To determine the impact of prolonged storage of large wastewater sample volume (900 mL) at −20 °C on enveloped virus decay, the BRSV seeded wastewaters samples were stored at −20 °C up to 110 days and analyzed using the most efficient concentration (protocol 9) and extraction (Zymo Quick-RNA kit) methods. BRSV RNA followed a first-order decay rate (k = 0.04/h with r2 = 0.99) in wastewater. Finally, 21 wastewater influent samples from five wastewater treatment plants (WWTPs) in southern Maryland, USA were analyzed between May to August 2020 to determine SARS-CoV-2 RNA concentrations. SARS-CoV-2 RNA was quantifiable in 17/21 (81%) of the influent wastewater samples with concentration ranging from 1.10 (±0.10) × 104 to 2.38 (±0.16) × 106 gene copies/L. Among the RT-qPCR assays tested, US CDC N1 assay was the most sensitive followed by US CDC N2, E_Sarbeco, and RdRp assays. Data presented in this study may enhance our understanding on the effective concentration and extraction of SARS-CoV-2 from wastewater.

Title: Sodium hypochlorite disinfection of SARS-CoV-2 spiked in water and municipal wastewater
Authors: Greaves J., Fischer R.J., Shaffer M., Bivins A. Holbrook M.G., Munster V.J. Bibby K.
Source: Science of the Total Environment, Volume 807, 10 February 2022

Abstract:
Infectious severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has the potential to be collected in wastewater from mucus, sputum, and feces of infected individuals, raising questions about the appropriate handling and treatment of the resulting wastewater. Current evidence indicates the likelihood of waterborne SARS-CoV-2 transmission is low; nonetheless, confirming the efficacy of disinfection against SARS-CoV-2 is prudent to ensure multiple barriers of protection for infectious SARS-CoV-2 that could be present in municipal and hospital wastewater. Sodium hypochlorite (free chlorine) is widely used for pathogen control in water disinfection applications. In the current study, we investigated the inactivation of SARS-CoV-2 in DI water and municipal wastewater primary influent by sodium hypochlorite (free chlorine) addition. Our results showed rapid disinfection of SARS-CoV-2, with less than 1 mg-min/L required for >3 log10 TCID50 reduction in DI water. More than 5 mg-min/L was required for 3 log10 TCID50 reduction in primary influent, suggesting potential shielding of the virus by suspended solids. These results are consistent with expected virus inactivation by free chlorine and suggest the adequacy of free chlorine disinfection for inactivation of infectious SARS-CoV-2 in water matrices.

Title: SARS-CoV-2 variant detection at a university dormitory using wastewater genomic tools
Authors: Vo V. Tillett R.L. Chang C.-L. Gerrity D. Betancourt W. Q. Oh E.C.
Source: Science of the Total Environment, Volume 805,20 January 2022

Abstract:
In the Fall of 2020, university campuses in the United States resumed on-campus instruction and implemented wastewater monitoring for the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). While quantitative polymerase chain reaction (qPCR) tests were deployed successfully to detect viral RNA in wastewater across campuses, the feasibility of detecting viral variants from a residential building like a dormitory was unclear.

Here, we demonstrate that wastewater surveillance from a dormitory with at least three infected students could lead to the identification of viral genomes with more than 95% coverage. Our results indicate that viral variant detection from wastewater is achievable at a dormitory and that coronavirus disease 2019 (COVID-19) wastewater surveillance programs will benefit from the implementation of viral whole genome sequencing at universities.

Title: A comparison of four commercially available RNA extraction kits for wastewater surveillance of SARS-CoV-2 in a college population.
Authors: O'Brien M. Rundell Z.C. Nemec M.D. Langan L.M. Back J.A. Lugo J.N.
Source: Science of the Total Environment, Volume 801, 20 December 2021

Abstract:
Localized wastewater surveillance has allowed for public health officials to gain a broader understanding of SARS-CoV-2 viral prevalence in the community allowing public health officials time to prepare for impending outbreaks. Given variable levels of virus in the population through public health interventions, proper concentration and extraction of viral RNA is a key step in ensuring accurate detections. With many commercial RNA extraction kits and methodologies available, the performance of 4 different kits were evaluated for SARS-CoV-2 RNA detection in wastewater, specifically focusing on their applicability to lower population densities such as those at university campus dorms. Raw wastewater samples were collected at 4 sites on a college campus over a 24 hour period as a composite sample. Included in these sites was an isolation site that housed students that tested positive for Covid-19 via nasopharyngeal swabs. These samples were analyzed using the following kits: Qiagen All Prep PowerViral DNA/RNA kit, New England BioLabs Monarch RNA MiniPrep Kit, and Zymo Quick RNA-Viral Kit, and the Zymo Quick-RNA Fecal/Soil Microbe MicroPrep Kit. All four sites were processed according to the manufacturer's guidelines. Extractions were then quantified with RT-qPCR one-step reactions using an N2 primer and a linearized plasmid standard. While the Zymo Quick-RNA Fecal/Soil Microbe MicroPrep Kit (also known as the Zymo Environ Water RNA Kit) only recovered approximately 73% (±38%) SARS-CoV-2 RNA compared to the Zymo Quick-RNA Viral kit, it was the most time efficient kit to yield comparable results. This extraction kit had a cumulative processing time of approximately 5 h compared, while the other three kits had processing times between approximately 9 and 9.5 h. Based on the current research, the most effective kits for smaller population densities are pellet based and include a homogenization, inhibitor removal, and RNA preservation step

Title: Comparative effectiveness of membrane technologies and disinfection methods for virus elimination in water: A review
Authors: Chen C., Guo L., Yang Y., Oguma K., Hou L.-A.
Source: Science of the Total Environment, Volume 801, 20 December 2021

Abstract:
The pandemic of the 2019 novel coronavirus disease (COVID-19) has brought viruses into the public horizon. Since viruses can pose a threat to human health in a low concentration range, seeking efficient virus removal methods has been the research hotspots in the past few years. Herein, a total of 1060 research papers were collected from the Web of Science database to identify technological trends as well as the research status. Based on the analysis results, this review elaborates on the state-of-the-art of membrane filtration and disinfection technologies for the treatment of virus-containing wastewater and drinking water. The results

evince that membrane and disinfection methods achieve a broad range of virus removal efficiency (0.5–7 log reduction values (LRVs) and 0.09–8 LRVs, respectively) that is attributable to the various interactions between membranes or disinfectants and viruses having different susceptibility in viral capsid protein and nucleic acid. Moreover, this review discusses the related challenges and potential of membrane and disinfection technologies for customized virus removal in order to prevent the dissemination of the waterborne diseases.

Title: Prokaryotic viruses impact functional microorganisms in nutrient removal and carbon cycle in wastewater treatment plants
Authors: Chen Y. Wang Y. Paez-Espino D. Polz M.F. Zhang T.
Source: Nature Communications, Volume 12, Issue 1, December 2021

Abstract:
As one of the largest biotechnological applications, activated sludge (AS) systems in wastewater treatment plants (WWTPs) harbor enormous viruses, with 10-1,000-fold higher concentrations than in natural environments. However, the compositional variation and host-connections of AS viruses remain poorly explored. Here, we report a catalogue of ~50,000 prokaryotic viruses from six WWTPs, increasing the number of described viral species of AS by 23-fold, and showing the very high viral diversity which is largely unknown (98.4-99.6% of total viral contigs). Most viral genera are represented in more than one AS system with 53 identified across all. Viral infection widely spans 8 archaeal and 58 bacterial phyla, linking viruses with aerobic/anaerobic heterotrophs, and other functional microorganisms controlling nitrogen/phosphorous removal. Notably, Mycobacterium, notorious for causing AS foaming, is associated with 402 viral genera. Our findings expand the current AS virus catalogue and provide reference for the phage treatment to control undesired microorganisms in WWTPs.

Title: A review on detection of SARS-CoV-2 RNA in wastewater in light of the current knowledge of treatment process for removal of viral fragments
Authors: Sangkham S.
Source: Journal of Environmental Management, Volume 299, 1 December 2021

Abstract:
The entire globe is affected by the novel disease of coronavirus 2019 (COVID-19 or 2019-nCoV), which is formally recognised as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The World Health Organisation (WHO) announced this disease as a global pandemic. The presence of SARS-CoV-2 RNA in unprocessed wastewater has become a cause of worry due to these emerging pathogens in the process of wastewater treatment, as reported in the present study. This analysis intends to interpret the fate, environmental factors and route of transmission of SARS-CoV-2, along with its eradication by treating the wastewater for controlling and preventing its further spread. Different recovery estimations of the virus have been depicted by the detection of SARS-CoV-2 RNA in wastewater through the viral concentration techniques. Most frequently used viral concentration techniques include polyethylene glycol (PEG) precipitation, ultrafiltration, electronegative membrane, and ultracentrifugation, after which the detection and quantification of SARS-CoV-2 RNA are done in wastewater samples through quantitative reverse transcription-polymerase chain reaction (RT-qPCR). The wastewater treatment plant (WWTP) holds the key responsibility of eliminating pathogens prior to the discharge of wastewater into surface water bodies. The removal of SARS-CoV-2 RNA at the treatment stage is dependent on the operations of wastewater treatment systems during the outbreak of the virus; particularly, in the urban and

extensively populated regions. Efficient primary, secondary and tertiary methods of wastewater treatment and disinfection can reduce or inactivate SARS-CoV-2 RNA before being drained out. Nonetheless, further studies regarding COVID-19-related disinfectants, environment conditions and viral concentrations in each treatment procedure, implications on the environment and regular monitoring of transmission need to be done urgently. Hence, monitoring the SARS-CoV-2 RNA in samples of wastewater under the procedure of wastewater-based epidemiology (WBE) supplement the real-time data pertaining to the investigation of the COVID-19 pandemic in the community, regional and national levels.

Title: Technologies for recovery and reuse of plant nutrients from human excreta and domestic wastewater: a protocol for a systematic map and living evidence platform

Authors: Macura B., Thomas J. Metson G.S. McConville J.R. Johannesdottir S.L. Seddon D. Harder R.

Source: Environmental Evidence, Volume 10, Issue 1, December 2021

Abstract:
Background: Research and development on the recovery and reuse of nutrients found in human excreta and domestic wastewater has intensified over the past years, continuously producing new knowledge and technologies. However, research impact and knowledge transfer are limited. In particular, uptake and upscaling of new and innovative solutions in practice remain a key challenge. Achieving a more circular use of nutrients thus goes beyond technological innovation and will benefit from a synthesis of existing research being readily available to various stakeholders in the field. The aim of the systematic map and online evidence platform described in this protocol is threefold. First, to collate and summarise scientific research on technologies that facilitate the recovery and reuse of plant nutrients and organic matter found in human excreta and domestic and municipal wastewater. Second, to present this evidence in a way that can be easily navigated by stakeholders. Third, to report on new relevant research evidence to stakeholders as it becomes available. Methods: Firstly, we will produce a baseline systematic map, which will consist of an extension of two previous related syntheses. In a next stage, with help of machine learning and other automation technologies, the baseline systematic map will be transformed into 'living mode' that allows for a continually updated evidence platform. The baseline systematic map searches will be performed in 4 bibliographic sources and Google Scholar. All searches will be performed in English. Coding and meta-data extraction will include bibliographic information, locations as well as the recovery and reuse pathways. The living mode will mostly rely on automation technologies in EPPI-Reviewer and the Microsoft Academic database. The new records will be automatically identified and ranked in terms of eligibility. Records above a certain 'cut-off' threshold will be manually screened for eligibility. The threshold will be devised based on the empirically informed machine learning model. The evidence from the baseline systematic map and living mode will be embedded in an online evidence platform that in an interactive manner allows stakeholders to visualise and explore the systematic map findings, including knowledge gaps and clusters.

Title: Green nanoparticles in water treatment: A review of research trends, applications, environmental aspects and large-scale production

Authors: Magalhães-Ghiotto G.A.V., Oliveira A.M.D. Natal J.P.S. Bergamasco R. Gomes R.G.

Source: Environmental Nanotechnology, Monitoring and Management Volume 16, December 2021

Abstract:
It is noteworthy that the scarcity of water resources, especially due to the progressive environmental destruction associated with human consumption practices, is closely related to a loss of life quality and a reduction of socioeconomic development on a worldwide scale. Measures are being taken to mitigate this current scenario, among which is the wastewater treatment (domestic, urban and industrial effluents). However, most of the available treatments use chemicals that negatively impact the environment, are little effective, and still expensive for most countries. Both drinking water and wastewater require implementation of actions that incorporate less polluting, more efficient, low-cost and more applicable treatments. In this review, the use of nanotechnology in new water and effluent treatment techniques was addressed, discussing the problems commonly found in the literature. The leaching of nanoparticles related to environmental toxicity, the need to use green adsorbents that vary from raw material used in the synthesis of nanocomposites as well as the use of green routes, are some examples. The production of highly efficient particles, a low cost of production and expressive regeneration power are of great importance for directing research that move from bench scales to large-scale and industrial applications, so that these new techniques can truly benefit the environment and society.

Title: From mathematical models to policy design: Predicting greywater reuse scheme effectiveness and water reclamation benefits based on individuals' preferences
Authors: Amaris G., Dawson R. Gironás J. J.,Hess S. Ortúzar J.D.D.
Source: Sustainable Cities and Society, Volume 74, November 2021

Abstract:
The residential reuse of greywater has attracted interest in recent years as a strategy to face water security problems. Nowadays, some cities such as Santiago de Chile are seeking to promote new laws that allow residential greywater reuse and make the incorporation of the necessary infrastructure (machinery and a parallel pipe system) mandatory for new buildings. The success of any such schemes, in terms of the amount of mains water that can be saved, is clearly influenced by the decision that individual consumers make on whether or not to use the parallel system, as they will also be the ones to face the potential externalities produced by the system (e.g., odours, noise from technology). Understanding and anticipating the behaviour of individuals is not an easy task, especially in the context of systems not yet widely implemented, but the groundwork has been laid with the application of approaches that allow analysts to determine the heterogeneity in consumer preferences based on the qualities of the product or service. However, there has been a lack of focus on making predictions that quantify the impact of acceptability on the volume of water recovered, driven in part by methods that been applied. This paper presents a way of predicting policy effectiveness and potential greywater reclaim benefits based on individuals' preferences. For this, we use two existing models that allow us to make predictions of greywater reuse for different domestic purposes. In a case study application to the city of Santiago de Chile, we carry out scenario tests to predict the potential uptake under potential future policy settings and show how allowing for an additional permitted use of greywater could save several hundred litres of water per month per household.

Title: Ecological sanitation: Closing the loop in domestic wastewater management
Authors: Taşeli B.K.
Source: Advances in Environmental Research, Volume 81, Pages 173 – 190, 15 June 2021

Abstract:
According to the EcoSan (Ecological Sanitation) approach, which has been on the agenda in recent years and adopts ecological domestic wastewater management, domestic wastewater is not a pollutant but a resource that can be re-evaluated and used. In this approach, issues such as the completion of control and nutrient cycles at the source also come to the fore. Accordingly, it is recommended to collect the domestic wastewater by separating it into fractions at its source and to be reused by performing a series of processes appropriate to the characteristics of each fraction. Ecological sanitation systems benefit agriculture by allowing all nutrients to be fully recovered from faeces, urine and gray water, while minimizing water pollution and allowing water to be reused, especially for irrigation. The yellowwater contains the highest proportion of nutrients (nitrogen, phosphorus and potassium), which are directly available to plants and equally effective as mineral fertilizers. The brownwater mainly comprises of human faeces. The grey water from washing, rinsing, and shower drains, while representing the largest fraction of the total wastewater flow, has only a very low nutrient content. Therefore, it can be treated by simple techniques such as constructed wetlands, waste water ponds, biological treatment, membrane technology, filters and biofilms and is thereafter ready for reuse as service water and for irrigation purposes and may also be discharged into surrounding watercourses. The brownwater consists mainly of faeces which are the predominant source of pathogens of all streams of domestic wastewater and therefore responsible for the major hygienic hazards. It is also rich in organics, nutrients and trace elements. Anaerobic digestion is the controlled break down of organic matter in the absence of oxygen to produce a combustible biogas and nutrient rich organic by product. Converting faeces into biogas and using urine as a substitute for mineral fertilizer will contribute to the reduction of greenhouse gas emissions (CO2, CH4 and N2O). EcoSan can therefore be promoted according to Article 2 of Kyoto Protocol which denotes "Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies; Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy." EcoSan can also be regarded as clean production mechanism under Article 12 of Kyoto Protocol.

Title: Clogging in subsurface wastewater infiltration beds: genesis, influencing factors, identification methods and remediation strategies
Authors: Li Y.- H.,Peng L.-L. Li H.-B. Liu D.-Z.
Source: Water Science and Technology, Volume 83, Issue 10, Pages 2309 – 2326, 15 May 2021

Abstract:
Subsurface wastewater infiltration (SWI) is an environmentally friendly technology for the advanced treatment of domestic sewage. Clogging (including physical, chemical and biological clogging) of the porous medium not only directly reduces the hydraulic load (treatment efficiency), but also reduces the service life. Although clogging has become one of the key issues discussed in several reports, there are still several gaps in understanding,

especially in its occurrence process and identification. SWI clogging causes, development process and solutions are different from those of constructed wetlands. This article quotes some reports on constructed wetlands to provide technical ideas and reference for revealing SWI clogging problems. Based on the analysis of the clogging genesis, this review gathers the main factors that affect the degree of clogging, and new methods for the identification of clogging conditions. Some preventive and unclogging measures/strategies are presented. Finally, it is suggested that to effectively alleviate the clogging phenomenon and extend the service life, priority should be given to the comprehensive analysis of wastewater quality and solid constituents accumulated in the pores. Then, the effectiveness of in-situ strategies, such as alternating operation will be the main focuses of future research.

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