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Chapter Five - Impact of wastewater irrigation on soil attributes

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Abstract

Changing climatic conditions, continuously increasing human population, and industrialization have led to rising demand of water for different purposes including domestic and industrial ones. The water used in different processes ultimately becomes unfit for direct human consumption purposes. However, large amount of wastewater generated can be utilized for irrigation in agricultural activities to accomplish the need of fresh water. Irrigation with wastewater has considerable potential to improve the crop productivity in an order to achieve the goal of global food security. Although, the presence of useful micronutrients and macronutrients in wastewater may enhance the soil productivity, nevertheless, the availability of hazardous metals, pathogenic microbes, and the genes conferring resistance to antibiotics and pesticides may put the agroecosystem at environmental risk by modulating microbial community characteristics and food chain contamination. Furthermore, continuous irrigation with wastewater may result in substantial changes in soil physical, chemical, and biological characteristics. Such environmental risks can be minimized to a greater extent by employing suitable wastewater treatment techniques. The present chapter deals with different sources of wastewater generation, physico-chemical characteristics, and finally the impact of wastewater on different soil characteristics.

Previous Next

Keywords

Agroecosystem; Bioaccumulation; Metal contamination; Nutrient cycling; Soil microbes

1. Introduction

Freshwater resources around the globe are not equally distributed. The demand for freshwater is far high than the current availability of water in very large population of the world.[1] Restricted availability of freshwater is supposed to substantially compromise the human life activities and development prospects.[2] As per literature report, around 60% of the global population is expected to experience the physical unavailability of freshwater by the year 2025.3, 4 Out of nearly 70% freshwater employed for irrigation, agriculture sector consumes the biggest proportion. However, some of the countries utilize greater than 95% of the generated water.[5] Strikingly, the competition for share of freshwater in municipal, industrial, and agriculture activities is already high in water stressed region of the globe causing the production of large amount of wastewater. The continuous depletion of freshwater resources, therefore, calls for the application of alternative water sources including wastewater generated from different paths in agriculture, particularly in developing countries.6, 7 For instance, large numbers of small scale farmers belonging to water stressed area are relied on wastewater for crop irrigation.8, 9

Large amount of wastewater generated globally is either produced by domestic or industrial activities. Domestic wastewater, generally enriched with carbon, nitrogen, and phosphorus, is originated from different appliances including wash basins, washing machines, kitchen sinks, shower, and bath, apart from human originated excretory products.10, 11 For convenience, the domestic wastewater can be divided into black water and gray water types depending upon source and level of contamination.[12] The organic material and nutrient content is relatively high in black water as compared to gray water.[13] Considerably huge amount of industrial wastewater is generated after utilization in diverse industries for intended purposes. Generally, the industrial wastewater is categorized in two major types, i.e., inorganic and organic. Inorganic industrial wastewater is originated mainly from metallic and non metallic operations, whereas industrial wastewater of organic type is released during chemical synthesizing processes requiring organic counterparts. Important wastewater sources of industrial origin comprise of fertilizer, pharmaceuticals, slaughterhouses, mining, petrochemical, paper and pulp, leather, and textile based industries.14, 15, 16, 17, 18, 19

The inadequacy and uneven distribution of fresh water has directed the application of wastewater derived from different sources for agricultural irrigation. Crop irrigation with wastewater to fulfill the rising water shortage is reported by different researchers.20, 21, 22 However, irrigation with wastewater holds multiple advantages and challenges due to possible modulation in soil natural characteristics. The investigations of Libutti et al.[23] have showed higher concentration of soil chemicals after irrigation with wastewater in comparison to freshwater irrigation, suggesting proper treatment prior to field application. A study on the impact of irrigation with treated wastewater presented insignificant effect on soil characteristics, except increased electrical conductivity and sodium absorption ratio.[24] Thus, the irrigation with treated wastewater may impose negative influences not only on the physico-chemical attributes but also on biological characteristics of soil.[21] Further, different kinds of inorganic and organic contaminant may be introduced in soil even after irrigation with treated wastewater.25, 26 On the other hand, advantageous impact of treated wastewater irrigation on soil and plant characteristics is also described.27, 28 The contrasting effect of wastewater irrigation on soil and plant attributes, therefore, suggests the application of suitable treatment technology along with the introduction of state of art analytical technology to eliminate the negative consequences, if any. The present chapter is an attempt to shed light on different sources of wastewater, characteristic feature, and influences on soil characteristics.

2. Sources of wastewater

2.1. Domestic sources

Because of continuously rising human population, considerably increased quantity of domestic wastewater is released, especially in developed cities.[29] Residential settings are considered to release around 75% of domestic wastewater, whereas remaining is generated from official settlements, public workplaces, and commercial places.[30] Domestic wastewater falling in the category of gray water and black water is released during washing activity from sources like hand wash basins, kitchen, body washing, washing machines, and toilets. Gray water accounts for 50–80% of domestic wastewater and contains nitrogen, phosphorus, potassium, and organic matter ranging from 9 to 14%, 20–32%, 18–22%, and 29–62%, respectively.31, 32, 33 Typically, gray water possesses reduced amount of suspended solids and have lowered turbidity, suggesting the presence of dissolved contaminants to a greater extent. The quantity of gray water is nearly one to sevenfolds higher in comparison to black water.[34] The quality of gray water generated from different sources differs with reference to geography, characteristics of human population, and distribution pattern.[35]

2.2. Industrial sources

Industrial development is regarded as backbone to global economy. Industries are important contributors to excessive generation of wastewater after use of freshwater for different processes. Industries account for approximately 28% of wastewater out of 80% of global wastewater production.[36] As per an estimate of United Nations, the need of water for industries would raise upto 19% of worldwide water requirement in the year 2020.[37] A number of industries including pharmaceuticals, textile, mining, sugar, and leather are well documented for enormous production of wastewater. The composition of industrial wastewater from different sources varies significantly according to the nature of substrate utilized.

2.2.1. Fertilizer industry

Fertilizer industries are known to contribute a massive volume of wastewater with diverse chemical characteristics. The wastewater effluents possess varying concentrations of alcoholic contaminants, nitrogenous substances like ammonia and nitrate, acids, salts, phosphorus, and hazardous heavy metals including copper, zinc, aluminum posing undesirable threat to natural environment.38, 39, 40 Chemical characterization of effluents from various sources by authors presented chemical oxygen demand (COD) ranging from 50 to 1.4×10^5 mg/L and NH_3-N between 6.0 and 1700 mg/L. Moreover, varying levels of inorganic contaminants like fluoride, sulfate, sodium, potassium, calcium, and magnesium have also been reported in fertilizer industry wastewater.

2.2.2. Pharmaceutical industry

Pharmaceutical industries directed toward the synthesis of useful drugs for the management of health disorders are known to use excessive volumes of freshwater, eventually releasing wastewater. Pharmaceutical industries are estimated to consume nearly 22% of the entire industrial freshwater utilization. Pharmaceutical wastewater may contain varying concentration of antibiotics, hormones, anti-inflammatory drugs of steroidal and non-steroidal nature, beta blockers, antidepressants, and antihistamines.41, 42, 43, 44, 45

2.2.3. Animal slaughterhouses

On a global scale, nearly 30% of total freshwater is utilized in industries concerned with meat processing.46, 47 Interestingly, 62 Mm^3 of water is consumed annually in meat processing industries.[48] The worldwide production of meat based on beef, poultry, and pork industries has raised twofolds in preceding 10 years and is estimated to rise continuously by 2050. Therefore, expanding meat production is supposed to increase the production of wastewater from slaughterhouses[49] flourishing exceedingly in countries oriented toward meat as major diet. The wastewater originated from slaughterhouses differs substantially with respect to COD, BOD, phosphorus, total nitrogen content, organic carbon, and solids.50, 51, 52

2.2.4. Textile industry

Global annual production of dyes is estimated as 7×10^7 and 10^4 tons of synthesized dyes are consumed by textile industries.[53] Textile industries employ various types of chemically synthesized dyes and release heavy amount of colored wastewater containing different kinds of contaminants with persistent nature,54, 55 because of substantially reduced binding of colors to fabrics. The colored wastewater negatively influences photosynthetic activity and human health.[56] Further, the reduced penetration of light to lower water depth and compromised availability of oxygen affects the vital processes of aquatic flora and fauna. The problem may be exacerbated multifolds due to presence of certain heavy metals and chlorine used as the ingredients of synthetic dyes.[57]

2.2.5. Petrochemical industries

Petrochemical industries are ranked top among exceedingly rising sector essential for raising the economic output.[58] The presence of six oil and petroleum based industries among 10 large industries, signifies the global importance. Petrochemical industry wastewater enriched with multifarious organic material is reported to have high chemical oxygen demand (COD) and biological oxygen demand (BOD), therefore exert hazardous effects on environment and human health.59, 60, 61 The COD of petrochemical wastewater may reach as high as 11,500 mg/L. The organic components of petrochemical wastewater like toluene and xylene are of slow degradation nature and can influence the environmental complexes for longer durations.[62] Further, the wastewater from petroleum industries contains increased concentrations of phenols, benzene, solubilized minerals, volatile organic compounds, and polycyclic aromatic hydrocarbons.63, 64, 65

2.2.6. Mining industries

Mining processes including ore smelting generate wastewater containing increased concentrations of different heavy metals including cadmium, zinc, lead, arsenic, and copper.66, 67, 68, 69, 70 Coal mining areas are another source of wastewater, differing in composition according to geographical locations, mineral characteristics, and hydrological attributes.[71] Generally, mine wastewater is of acidic nature enriched with varied concentrations of heavy metals.[72] Discharge of large volumes of mine wastewater disturbs the ecological balance responsible for environmental degradation.

2.2.7. Paper and pulp industry

As the need of paper based products has risen with the time, establishment of newer industries are expected. Paper and pulp industry is recognized as one of the most water and energy demanding sector around the globe. Paper and pulp industry consumes high volumes of water leading to generation of wastewater in larger quantities. In this context, developing countries are considered to generate comparatively higher volumes of wastewater because of lessened reuse of wastewater and inefficient wastewater treatment technology. In general, one ton of paper production requires 5–100 m^3 of water and varies according to nature of substrate, quantity of paper formed, and potential of water reusability.[73]

Paper and pulp industry is identified as one of the sixth largest contributor to environmental pollution. The toxic effluents of complex chemical nature generated from paper and pulp based industry contain various inorganic and organic contaminants exerting unwanted effect on environment and human health.[74] Wastewater generated during bleaching process is registered to have high COD and suspended solids contributed by plant fibrous substances. The volume of wastewater produced after bleaching, generally contains chemical residues and constitutes approximately 25–35% of total wastewater effluent.[75] The paper and pulp industry wastewater include persistent chemical contaminants such as furan, resin, tannins, chlorophenols, and organic halogens.76, 77

2.2.8. Leather industry

Leather industry has important role in generating revenue, particularly in India.[78] The leather purification process consumes enormous quantity of water leading to generation of wastewater effluents reaching to

150 tons per day. In general, the processing of one ton of raw skin material generates 20,000–80,000 L of wastewater with undesirable odor and suspended materials.[79] Leather industry wastewater is characterized to have increased COD, BOD, reduced form of chromium, NaCl, calcium, magnesium, sulfide compounds, and other hazardous contaminants including oils, tannins, and biocides, posing detrimental effects on environment and humans.80, 81, 82

2.2.9. Sugar industry

Wastewater produced from sugar industry has greater potential to contaminate the environment. In India, an estimated 1000 L of wastewater is produced after industrial crushing of one ton sugar cane. Moreover, the production of one ton sugar is accompanied with the generation of 70 cubic meters wastewater enriched with organic substances.[83] The characteristic type of organic constituents and nature of sugar industry wastewater largely depend on the operating conditions and utilized raw substrates. The COD and BOD values of wastewater reaching as high as 4850 and 1950 mg/L, respectively is registered.[84] Additionally, the wastewater had high load of suspended solids, dissolved solids, and organic carbon. As the direct discharge of untreated sugarcane wastewater exerts negative effect on both terrestrial and aquatic environment,[85] proper treatment before final discharge is suggested.

3. Impact of wastewater irrigation on soil characteristics

Wastewater has important opportunities not only in fulfilling the shortage of huge amount of water required in agricultural irrigation, but also in supplementing necessary nutrients. The introduction of wastewater as source of water for soil irrigation is widely reported and is much commonly practiced in developing countries because of high wastewater treatment cost.86, 87 Therefore, wastewater irrigation may be considered as an effective strategy to reduce soil degradation and vital nutrient depletion after continuous cropping.[25] Wastewater released from different sources ultimately reaches to aquatic and terrestrial ecosystems causing ill effects. The presence of various soluble and insoluble substances, heavy metals, pesticides, pharmaceuticals, dyes, and volatile substances in wastewater are expected to modulate the soil physical, chemical, and biological characteristics after irrigation.88, 89, 90 The studies on effect of wastewater on different soil physico-chemical attributes are described in following sections.

3.1. Effect on physico-chemical characteristics

Investigation of Angin et al.[25] has reported rise in salinity and reduction in soil pH after wastewater irrigation. In addition, there was substantial rise in organic matter, nitrogen content, positively charged ions, and heavy metal content of selected soil samples. The raised concentration of soil's heavy metals content suggested the treatment of wastewater before application for irrigation. Undesirable effects of treated fish processing wastewater on electrical conductivity and sodium adsorption ratio (SAR) are presented by Vallejos et al.[87] Rise in SAR value was observed after soil irrigation with wastewater causing transformation of non-saline soil to saline ones. The increased salinization in due course may alter soil structure and influence permeability, thereby inducing detrimental effects on organic matter synthesis by green plants.[91] Although, there was insignificant change in total soil carbon, significant reduction in organic carbon content was registered after wastewater irrigation. The irrigation was also noticed to induce reduction in carbon/nitrogen value of soil microcosm.

Impact of urine and coffee processing wastewater (1:2 ratio) irrigation on soil properties is demonstrated by Alemayehu et al.[92] Considerable increase in soil organic carbon (SOC) and available phosphorus was observed after wastewater irrigation. Further, the irrigation led to significant enhancement in soil salinity. The soil analysis showed changes in pH and total nitrogen by 0.16 and 0.07 units, respectively. However, no significant differences were recorded in micronutrient and cation exchange characteristics, except few cations.

Supplementation of brewing wastewater on soil attributes including % sand, % silt, % clay, bulk density, organic matter, pH, cations, and SAR is presented by Gorfie et al.[93] Wastewater irrigation reduced the bulk density of soil rendered by addition of organic matter. Organic matter and organic carbon was found to be highest in soil irrigated with wastewater in comparison to control. Significant rise in sodium, potassium, calcium, magnesium, chloride, nitrate nitrogen, and phosphorus content of soil was also registered after wastewater irrigation. Research has documented increment in soil organic matter, nitrogen, phosphorus, and potassium ranging from 34.9–64.9%, 40.7–57.2%, 67.6–390.0%, and 35.4–240.9%, respectively upon irrigation with swine wastewater at 0–20 cm depth.[94] Similarly, rise in soil salinity posing negative effect on soil characteristics was also described. Wastewater irrigation caused the accumulation of heavy metals including chromium, copper, zinc, lead, and cadmium ranging from 0.75% to 222.6%. Furthermore, long duration (5 years) supplementation of wastewater introduced the greater amount of tetracycline group of antibiotics in comparison to those soil irrigated for 3 years. The occurrence of heavy metals and antibiotics at depth greater than 100 cm implied downward migration and plausible contamination of groundwater. Experimental investigations conducted by Aman et al.[95] suggested the enhancement in cation exchange potential, electrical conductivity, and SAR after irrigation with industrial wastewater.

3.2. Effect on biological characteristics

The presence of myriads of inorganic and organic contaminants in wastewater originated from different locations after introduction in soil has the potential to modulate the soil biological attributes. Changes in microbial activity and community structure may directly or indirectly influence and govern the cycling of nutrients important for optimum biological functioning of soil.

The increase in soil microbial biomass and enzymes such as beta glucosidase and alkaline phosphatase following introduction of treated municipal wastewater has been marked by Adrover et al.[96] The modification in soil biological activity was mainly ascribed to addition of organic matter. Appraisal of the impact of treated wastewater irrigation on rhizospheric microbial community is recently documented.[97] Changes in microbial community structure were the resultant of modification in soil moisture and organic material content brought about by wastewater irrigation. Soil irrigation with wastewater imposed negative effect on abundance of actinobacteria members belonging to orders solirubrobacterales and gaiellales was probably linked with decline in microfauna population. Two folds rise in soil microbial biomass subsequent to field irrigation with tannery wastewater is endorsed by Alvarez-Bernal et al.[98] Nevertheless, organic carbon content and the enzymatic activities of proteases and hydrolases were found to be uninfluenced by wastewater irrigation. Analysis of the impact of wastewater irrigation on biological attributes suggested significant enhancement in basal respiration of soil,[28] rendered by increment in microbiological activity. In comparison to control, the enhancement was observed to fall in the range of 95–130% for different soil samples irrigated with treated wastewater. Congruent report on considerable rise in microbial processes after irrigation with treated wastewater is recently presented.[99] Application of reclaimed wastewater for irrigation was noticed to restrict the alteration in mycobiota characteristics of soil. The improved soil microbiological activities were supported by the introduction of organic matter, essential nutrients, and diverse microbes present in treated wastewater used for irrigation purposes. Furthermore, improved plant productivity and rhizodeposition directed by wastewater irrigation was also important factor responsible for raised microbial community activity. Contrasting effects of irrigation with wastewater on microbial activity is presented by different researchers. Some of the investigations have indicated the reduction in biomass and activity of soil bacteria upon amendment of reclaimed wastewater.100, 101 On the other hand, augmentation in microbial activity[102] apart from insignificant impacts of wastewater irrigation on microbial quantity has also been demonstrated.103, 104 The impact of treated wastewater irrigation on soil microbial characteristics is not consistent. The experimental investigation conducted by Xu et al.[105] has documented reductions in number of soil actinomycetes, fungi, nitrite oxidizing bacteria, nitrate bacteria, and those bacteria performing denitrification in contrast to rise in number of ammonia oxidizing bacteria and cellulose degrading bacteria as determined by most probable number after 20 years of irrigation with reclaimed wastewater. The contrasting effects of wastewater on soil biological features mainly result from considerable variation in chemical characteristics, suggesting the introduction of raw/treated wastewater to compatible agricultural sites in order to avoid soil degradation.

4. Conclusion and recommendations

Wastewater emanating from different industries may be considered as an important alternative to continuously depleting freshwater resources under the influence of rising human population, industrialization, and climate change. The reclaimed wastewater has immense potential to be employed in agricultural irrigation. The presence of varied inorganic and organic materials in wastewater holds the possibility to modify the soil characteristics. Short term and long term irrigation are described to exert varying effects on soil attributes. The irrigation with wastewater directly and after treatment possesses the ability to modify the physico-chemical features like pH, bulk density, electrical conductivity, field capacity, sodium adsorption ratio, ion exchange capacity, organic matter content, and macro/micronutrient composition. The continuous irrigation has the risks of adding unwanted contaminants like heavy metals, dyes, oils, persistent organic pollutants, and pharmaceuticals to a level responsible for soil degradation and eventually reduced soil productivity. Moreover, continued irrigation may contaminate the groundwater resources with hazardous contaminants. The presence of sufficient organic and inorganic nutrients in wastewater is suggested to modulate the microbial community after introduction in soil. Alteration in microbial community characteristics induced by substantial changes in soil characteristics, therefore would affect the microbially assisted nutrient cycling. Investigations have shown both advantageous and negative contrasting effects on soil properties depending on the composition of wastewater. However, in the context of depleting soil nutrients and freshwater reserves, wastewater irrigation has multiple opportunities in managing soil and crop productivity.

Based on literature review, following recommendations can be made.

➢ A single kind of wastewater may not be suitable for all types of soil for irrigation purposes and vice versa.

➢ Wastewater should be introduced in soils after pretreatment. The level of contaminants of either organic or inorganic nature should be within the recommended limits.

➢ The impact of wastewater irrigation on soil properties should be monitored regularly in order to alleviate the hazardous impacts of contaminants.

➢ The transfer of noxious contaminants like heavy metals and antibiotics from soil to growing plants should be examined to prevent food chain contamination.

➢ The wastewater either treated or diluted should be preferred more for non-food plants such as ornamental plants rather than food crops.

➢ Study on long term effect of wastewater treatment on soil microbiological parameters is recommended for maintaining microbial activity, and nutrient cycling.

➢ Effect of wastewater irrigation on soil fauna is very less studied. Study of wastewater irrigation on key annelids and arthropods is necessary for conserving soil productivity.

➢ The contaminants of wastewater like heavy metals and antibiotics may be accumulated in soil higher than the recommended limits and may be transferred to food chain at an unacceptable level.

➢ The long term effect of wastewater irrigation on soil salinization and sodicity is warranted to conserve the natural soil productivity.

➢ High throughput analytical techniques should be developed to detect even the trace level of traditional as well as emerging contaminants in order to minimize the detrimental effects on human health and environment.

➢ Less expensive techniques for extracting the contaminants present in wastewater needs to be developed.

➢ Fate and transport of wastewater contaminants need extensive investigation to protect the soil from degradation.

➢ The assessment of transport of wastewater contaminants to lower soil depth and groundwater are inevitably required to restrict the contamination of soil and groundwater resources.

Volume chapters Recommended articles

References

1 A.J. Bennett
Environmental consequences of increasing production: some current perspectives
Agr Ecosyst Environ, 82 (1–3) (2000), pp. 89-95
View PDF View article Google Scholar

2 M. Qadir, B.R. Sharma, A. Bruggeman, R. Choukr-Allah, F. Karajeh
Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries
Agric Water Manag, 87 (1) (2007), pp. 2-22
View PDF View article View in Scopus Google Scholar

3 D. Pimentel, O. Bailey, P. Kim, E. Mullaney, J. Calabrese, L. Walman, *et al.*
Will limits of the earth's resources control human numbers?
Environ Dev Sustain, 1 (1) (1999), pp. 19-39
View in Scopus Google Scholar

4 F.R. Rijsberman
Water scarcity: fact or fiction?
Agric Water Manag, 80 (1–3) (2006), pp. 5-22
View PDF View article View in Scopus Google Scholar

5 FAO-AQUASTAT
Global information system on water and agriculture
http://www.fao.org/nr/water/aquastat/main/index.stm (2012)
accessed on 10.06.2022
Google Scholar

6 H. Al-Hamaiedeh, M. Bino
Effect of treated grey water reuse in irrigation on soil and plants
Desalination, 256 (1–3) (2010), pp. 115-119

View PDF View article View in Scopus ↗ Google Scholar ↗

7 O.R. Al-Jayyousi
Greywater reuse: towards sustainable water management
Desalination, 156 (1–3) (2003), pp. 181-192
View PDF View article View in Scopus ↗ Google Scholar ↗

8 P. Drechsel, C.A. Scott, L. Raschid-Sally, M. Redwood, A. Bahri
Wastewater irrigation and health: assessing and mitigating risk in low-income countries
Earthscan-International Development Research Centre (IDRC)-International Water Management Institute (IWMI) (2010)
Google Scholar ↗

9 L. Raschid-Sally, P. Jayakody
Drivers and characteristics of wastewater agriculture in developing countries: results from a global assessment
Research report 127, International Water Management Institute, Colombo (2008)
Google Scholar ↗

10 M.C. Almeida, D. Butler, E. Friedler
At-source domestic wastewater quality
Urban water, 1 (1) (1999), pp. 49-55
View PDF View article View in Scopus ↗ Google Scholar ↗

11 C.V.T. Do, M.H.T. Pham, T.Y.T. Pham, C.T. Dinh, T.U.T. Bui, T.D. Tran
Microalgae and bioremediation of domestic wastewater
Curr Opin Green Sustain Chem, 34 (2022), p. 100595
View PDF View article View in Scopus ↗ Google Scholar ↗

12 A. Maimon, A. Gross
Greywater: limitations and perspective
Curr Opin Environ Sci Health, 2 (2018), pp. 1-6
View PDF View article View in Scopus ↗ Google Scholar ↗

13 A. Butkovskyi, L. Sevenou, R.J.W. Meulepas, L. Hernandez Leal, G. Zeeman, H.H.M. Rijnaarts
Micropollutant removal from black water and grey water sludge in a UASB-GAC reactor
Water Sci Technol, 77 (4) (2018), pp. 1137-1148
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

14 S.I. Abou-Elela, E.M. El-Kamah, H.I. Aly, E. Abou-Taleb

Management of wastewater from the fertilizer industry
Water Sci Technol, 32 (11) (1995), pp. 45-54
View PDF View article CrossRef View in Scopus Google Scholar

15 L.B. Grossi, N.C. Magalhaes, B.M. Araujo, F. de Carvalho, L.H. Andrade, M.C. Amaral
Water conservation in mining industry by integrating pressure-oriented membrane processes for nitrogen-contaminated wastewater treatment: bench and pilot-scale studies
J Environ Chem Eng, 9 (1) (2021), p. 104779
View PDF View article View in Scopus Google Scholar

16 S.H.I. Hanchang
Industrial wastewater-types, amounts and effects
Point sources of pollution: Local effects and their control, vol. 2, EOLSS publisher/UNESCO (2009), p. 191
Google Scholar

17 R. Kishor, D. Purchase, G.D. Saratale, R.G. Saratale, L.F.R. Ferreira, M. Bilal, *et al.*
Ecotoxicological and health concerns of persistent coloring pollutants of textile industry wastewater and treatment approaches for environmental safety
J Environ Chem Eng, 9 (2) (2021), p. 105012
View PDF View article View in Scopus Google Scholar

18 U. Singh, R.S. Pandey
Fertilizer industry effluent induced hematological, histopathological and biochemical alterations in a stinging catfish, *Heteropneustes fossilis* (Bloch, 1794)
Environ Sustain Indic, 10 (2021), p. 100110
View PDF View article View in Scopus Google Scholar

19 R. Zou, K. Tang, A.C. Hambly, U.J. Wünsch, H.R. Andersen, I. Angelidaki, *et al.*
When microbial electrochemistry meets UV: the applicability to high-strength real pharmaceutical industry wastewater
J Hazard Mater, 423 (2022), p. 127151
View PDF View article View in Scopus Google Scholar

20 A. Dovlatabadi, E.H. Estiri, M.L. Najafi, A. Ghorbani, H. Rezaei, M. Behmanesh, *et al.*
Bioaccumulation and health risk assessment of exposure to potentially toxic elements by consuming agricultural products irrigated with wastewater effluents
Environ Res, 205 (2022), p. 112479
View PDF View article View in Scopus Google Scholar

21 L.P. Leonel, A.L. Tonetti
Wastewater reuse for crop irrigation: crop yield, soil and human health implications based on giardiasis epidemiology
Sci Total Environ, 775 (2021), p. 145833
View PDF View article View in Scopus ↗ Google Scholar ↗

22 S. Ofori, A. Puškáčová, I. Růžičková, J. Wanner
Treated wastewater reuse for irrigation: pros and cons
Sci Total Environ, 760 (2021), p. 144026
View PDF View article View in Scopus ↗ Google Scholar ↗

23 A. Libutti, G. Gatta, A. Gagliardi, P. Vergine, A. Pollice, L. Beneduce, *et al.*
Agro-industrial wastewater reuse for irrigation of a vegetable crop succession under Mediterranean conditions
Agric Water Manag, 196 (2018), pp. 1-14
View PDF View article View in Scopus ↗ Google Scholar ↗

24 M. Farhadkhani, M. Nikaeen, G. Yadegarfar, M. Hatamzadeh, H. Pourmohammadbagher, Z. Sahbaei, *et al.*
Effects of irrigation with secondary treated wastewater on physicochemical and microbial properties of soil and produce safety in a semi-arid area
Water Res, 144 (2018), pp. 356-364
View PDF View article View in Scopus ↗ Google Scholar ↗

25 I. Angin, A.V. Yaganoglu, M. Turan
Effects of long-term wastewater irrigation on soil properties
J Sustain Agric, 26 (3) (2005), pp. 31-42
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

26 P.S. Minhas, J.K. Saha, M.L. Dotaniya, A. Sarkar, M. Saha
Wastewater irrigation in India: current status, impacts and response options
Sci Total Environ, 808 (2022), p. 152001
View PDF View article View in Scopus ↗ Google Scholar ↗

27 T.P. Abegunrin, G.O. Awe, D.O. Idowu, M.A. Adejumobi
Impact of wastewater irrigation on soil physico-chemical properties, growth and water use pattern of two indigenous vegetables in Southwest Nigeria
Catena, 139 (2016), pp. 167-178
View PDF View article View in Scopus ↗ Google Scholar ↗

28 K. Ibrahimi, K.B. Attia, R. Amami, J.H.P. Américo-Pinheiro, F. Sher
Assessment of three decades treated wastewater impact on soil quality in semi-arid agroecosystem
J Saudi Soc Agric Sci (2022), 10.1016/j.jssas.2022.03.002
Google Scholar

29 P.K. Singh, P.B. Deshbhratar, D.S. Ramteke
Effects of sewage wastewater irrigation on soil properties, crop yield and environment
Agric Water Manag, 103 (2012), pp. 100-104
View PDF View article View in Scopus Google Scholar

30 S.M.S. Wirawan
Community preparation for domestic wastewater management development in Jakarta
Int J Innov Sci Res Technol, 5 (2020), pp. 133-143
CrossRef Google Scholar

31 E. Eriksson, K. Auffarth, A.M. Eilersen, M. Henze, A. Ledin
Household chemicals and personal care products as sources for xenobiotic organic compounds in grey wastewater
Water SA, 29 (2) (2003), pp. 135-146
View in Scopus Google Scholar

32 E. Friedler, M. Hadari
Economic feasibility of on-site greywater reuse in multi-storey buildings
Desalination, 190 (1–3) (2006), pp. 221-234
View PDF View article View in Scopus Google Scholar

33 K. Kujawa-Roeleveld, G. Zeeman
Anaerobic treatment in decentralised and source-separation-based sanitation concepts
Rev Environ Sci Bio/Technol, 5 (1) (2006), pp. 115-139
CrossRef View in Scopus Google Scholar

34 D.M. Ghaitidak, K.D. Yadav
Characteristics and treatment of greywater—a review
Environ Sci Pollut Res, 20 (5) (2013), pp. 2795-2809
CrossRef View in Scopus Google Scholar

35 B. Jefferson, A. Laine, S. Parsons, T. Stephenson, S. Judd
Technologies for domestic wastewater recycling
Urban Water, 1 (4) (2000), pp. 285-292

View PDF View article View in Scopus ↗ Google Scholar ↗

36 A. Shokri, M.S. Fard
A critical review in electrocoagulation technology applied for oil removal in industrial wastewater
Chemosphere, 288 (2022), p. 132355
View PDF View article View in Scopus ↗ Google Scholar ↗

37 UN-Water
The United Nations world water development report (2021) valuing water
UNESCO, Paris (2021)
https://www.unwater.org/publications/un-world-water-development-report-2021/ ↗
Google Scholar ↗

38 A.Y. Bagastyo, A.D. Anggrainy, C.S. Nindita
Electrodialytic removal of fluoride and calcium ions to recover phosphate from fertilizer industry wastewater
J Sustain Agric, 27 (5) (2017), pp. 230-237
View PDF View article CrossRef ↗ View in Scopus ↗ Google Scholar ↗

39 V.M. Bhandari, L.G. Sorokhaibam, V.V. Ranade
Industrial wastewater treatment for fertilizer industry—a case study
Desalin Water Treat, 57 (57) (2016), pp. 27934-27944
View in Scopus ↗ Google Scholar ↗

40 R. Fernández-González, M.A. Martín-Lara, G. Blázquez, G. Tenorio, M. Calero
Hydrolyzed olive cake as novel adsorbent for copper removal from fertilizer industry wastewater
J Clean Prod, 268 (2020), p. 121935
View PDF View article View in Scopus ↗ Google Scholar ↗

41 J.O. Eniola, R. Kumar, M.A. Barakat, J. Rashid
A review on conventional and advanced hybrid technologies for pharmaceutical wastewater treatment
J Clean Prod, 356 (2022), p. 131826
View PDF View article View in Scopus ↗ Google Scholar ↗

42 S.K. Khetan, T.J. Collins
Human pharmaceuticals in the aquatic environment: a challenge to green chemistry
Chem Rev, 107 (6) (2007), pp. 2319-2364

CrossRef ↗ View in Scopus ↗ Google Scholar ↗

43 Y. Praveenkumarreddy, K. Vimalkumar, B.R. Ramaswamy, V. Kumar, R.K. Singhal, H. Basu, *et al.*
Assessment of non-steroidal anti-inflammatory drugs from selected wastewater treatment plants of southwestern India
Emerg Contam, 7 (2021), pp. 43-51
View PDF View article View in Scopus ↗ Google Scholar ↗

44 R. Seenivasagan, R. Kasimani
A review on remedial techniques for pharmaceutical contaminants in wastewater
Organic pollutants, Springer, Cham (2022), pp. 373-397
CrossRef ↗ Google Scholar ↗

45 Q. Wu, Y. Zhang, M.H. Cui, H. Liu, H. Liu, Z. Zheng, *et al.*
Pyrolyzing pharmaceutical sludge to biochar as an efficient adsorbent for deep removal of fluoroquinolone antibiotics from pharmaceutical wastewater: performance and mechanism
J Hazard Mater, 426 (2022), p. 127798
View PDF View article View in Scopus ↗ Google Scholar ↗

46 M. Asselin, P. Drogui, H. Benmoussa, J.F. Blais
Effectiveness of electrocoagulation process in removing organic compounds from slaughterhouse wastewater using monopolar and bipolar electrolytic cells
Chemosphere, 72 (11) (2008), pp. 1727-1733
View PDF View article View in Scopus ↗ Google Scholar ↗

47 Ü.T. Ün, A.S. Koparal, Ü.B. Öğütveren
Hybrid processes for the treatment of cattle-slaughterhouse wastewater using aluminum and iron electrodes
J Hazard Mater, 164 (2–3) (2009), pp. 580-586
Google Scholar ↗

48 R.F. De Sena, J.L. Tambosi, A.K. Genena, R. de FPM Moreira, H.F. Schröder, H.J. José
Treatment of meat industry wastewater using dissolved air flotation and advanced oxidation processes monitored by GC–MS and LC–MS
Chem Eng J, 152 (1) (2009), pp. 151-157
View PDF View article View in Scopus ↗ Google Scholar ↗

49 R. Alvarez, G. Liden

Semi-continuous co-digestion of solid slaughterhouse waste, manure, and fruit and vegetable waste
Renew Energy, 33 (4) (2008), pp. 726-734
View PDF View article View in Scopus ↗ Google Scholar ↗

50 C.F. Bustillo-Lecompte, M. Mehrvar
Slaughterhouse wastewater characteristics, treatment, and management in the meat processing industry: a review on trends and advances
J Environ Manage, 161 (2015), pp. 287-302
View PDF View article View in Scopus ↗ Google Scholar ↗

51 J. Ramaswamy, V. Solaiappan, G. Albasher, O. Alamri, N. Alsultan, K. Sathiasivan
Process optimization of struvite recovered from slaughterhouse wastewater and its fertilizing efficacy in amendment of biofertilizer
Environ Res, 211 (2022), p. 113011
View PDF View article View in Scopus ↗ Google Scholar ↗

52 M.A. Sandoval, L.C. Espinoza, O. Coreño, V. García, R. Fuentes, A. Thiam, *et al.*
A comparative study of anodic oxidation and electrocoagulation for treating cattle slaughterhouse wastewater
J Environ Chem Eng, 10 (2022), p. 108306
View PDF View article View in Scopus ↗ Google Scholar ↗

53 V. Chandanshive, S. Kadam, N. Rane, B.H. Jeon, J. Jadhav, S. Govindwar
In situ textile wastewater treatment in high rate transpiration system furrows planted with aquatic macrophytes and floating phytobeds
Chemosphere, 252 (2020), p. 126513
View PDF View article View in Scopus ↗ Google Scholar ↗

54 S.S. Ali, R. Al-Tohamy, J. Sun
Performance of *Meyerozyma caribbica* as a novel manganese peroxidase-producing yeast inhabiting wood-feeding termite gut symbionts for azo dye decolorization and detoxification
Sci Total Environ, 806 (2022), p. 150665
View PDF View article View in Scopus ↗ Google Scholar ↗

55 B.C. Almroth, J. Cartine, C. Jönander, M. Karlsson, J. Langlois, M. Lindström, *et al.*
Assessing the effects of textile leachates in fish using multiple testing methods: from gene expression to behavior

Ecotoxicol Environ Saf, 207 (2021), p. 111523

Google Scholar ↗

56 R. Al-Tohamy, S.S. Ali, F. Li, K.M. Okasha, Y.A.G. Mahmoud, T. Elsamahy, *et al.*
A critical review on the treatment of dye-containing wastewater: Ecotoxicological and health concerns of textile dyes and possible remediation approaches for environmental safety
Ecotoxicol Environ Saf, 231 (2022), p. 113160

View PDF View article View in Scopus ↗ Google Scholar ↗

57 C.R. Holkar, A.J. Jadhav, D.V. Pinjari, N.M. Mahamuni, A.B. Pandit
A critical review on textile wastewater treatments: possible approaches
J Environ Manage, 182 (2016), pp. 351-366

View PDF View article View in Scopus ↗ Google Scholar ↗

58 S. Varjani, R. Joshi, V.K. Srivastava, H.H. Ngo, W. Guo
Treatment of wastewater from petroleum industry: current practices and perspectives
Environ Sci Pollut Res, 27 (22) (2020), pp. 27172-27180

CrossRef ↗ View in Scopus ↗ Google Scholar ↗

59 T. Biswas, S. Banerjee, A. Saha, A. Bhattacharya, C. Chanda, L.M. Gantayet, *et al.*
Bacterial consortium based petrochemical wastewater treatment: from strain isolation to industrial effluent treatment
Environ Adv, 7 (2022), p. 100132

View PDF View article View in Scopus ↗ Google Scholar ↗

60 P. Ghosh, A.N. Samanta, S. Ray
COD reduction of petrochemical industry wastewater using Fenton's oxidation
Can J Chem Eng, 88 (6) (2010), pp. 1021-1026

CrossRef ↗ View in Scopus ↗ Google Scholar ↗

61 A.G. Kumi, M.G. Ibrahim, M. Fujii, M. Nasr
Petrochemical wastewater treatment by eggshell modified biochar as adsorbent: atechno-economic and sustainable approach
Adsorpt Sci Technol, 2022 (2022), pp. 1-13, 10.1155/2022/2323836 ↗

Google Scholar ↗

62 P.M. Stähelin, A. Valério, S.M.D.A.G. Ulson, A. da Silva, J.A.B. Valle, A.A.U. de Souza
Benzene and toluene removal from synthetic automotive gasoline by mono and

bicomponent adsorption process
Fuel, 231 (2018), pp. 45-52
View PDF View article View in Scopus Google Scholar

63 F. Qaderi, A.H. Sayahzadeh, M. Azizi
Efficiency optimization of petroleum wastewater treatment by using of serial moving bed biofilm reactors
J Clean Prod, 192 (2018), pp. 665-677
View PDF View article View in Scopus Google Scholar

64 P. Singh, V.K. Singh, R. Singh, A. Borthakur, A. Kumar, D. Tiwary, *et al.*
Biological degradation of toluene by indigenous bacteria Acinetobacter junii CH005 isolated from petroleum contaminated sites in India
Energy, Ecol Environ, 3 (3) (2018), pp. 162-170
CrossRef View in Scopus Google Scholar

65 F.G. Wessman, E. Yan Yuegen, Q. Zheng, G. He, T. Welander, B. Rusten
Increasing the capacity for treatment of chemical plant wastewater by replacing existing suspended carrier media with Kaldnes moving bed (TM) media at a plant in Singapore
Water Sci Technol, 49 (11–12) (2004), pp. 199-205
CrossRef View in Scopus Google Scholar

66 X.F. Hu, Y. Jiang, Y. Shu, X. Hu, L. Liu, F. Luo
Effects of mining wastewater discharges on heavy metal pollution and soil enzyme activity of the paddy fields
J Geochem Explor, 147 (2014), pp. 139-150
View PDF View article View in Scopus Google Scholar

67 Y.T. Li, T. Becquer, C. Quantin, M. Benedetti, P. Lavelle, J. Dai
Effects of heavy metals on microbial biomass and activity in subtropical paddy soil contaminated by acid mine drainage
Acta Ecol Sin, 24 (11) (2004), pp. 2430-2436
Google Scholar

68 C. Xu, B.C. Xia, J.Q. Qin, S. He, H. Li, X.F. Lin
Analysis and evaluation on heavy metal contamination in paddy soils in the lower stream of Dabaoshan area, Guangdong Province
J Agro-Environ Sci, 26 (2007), pp. 549-553
View in Scopus Google Scholar

69 A. Zahoor, G. Mao, X. Jia, X. Xiao, J.L. Chen
Global research progress on mining wastewater treatment: a bibliometric analysis
Environ Sci: Adv, 1 (2022), pp. 92-109
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

70 J.-M. Zhou, D. Zhi, C.A.I. Mei-Fang, L.I.U. Cong-Qiang
Soil heavy metal pollution around the Dabaoshan mine, Guangdong province, China
Pedosphere, 17 (5) (2007), pp. 588-594
View PDF View article View in Scopus ↗ Google Scholar ↗

71 S. Zhang, Q. Wu, H. Ji
Research on zero discharge treatment technology of mine wastewater
Energy Rep, 8 (2022), pp. 275-280
View PDF View article View in Scopus ↗ Google Scholar ↗

72 L. Yin, W. Li, S. Lin, G. Owens, Z. Chen
Simultaneous removal of arsenite and arsenate from mining wastewater using ZIF-8 embedded with iron nanoparticles
Chemosphere, 304 (2022), p. 135269
View PDF View article View in Scopus ↗ Google Scholar ↗

73 R. Toczyłowska-Mamińska
Limits and perspectives of pulp and paper industry wastewater treatment–a review
Renew Sustain Energy Rev, 78 (2017), pp. 764-772
View PDF View article View in Scopus ↗ Google Scholar ↗

74 P. Sharma, H.M. Iqbal, R. Chandra
Evaluation of pollution parameters and toxic elements in wastewater of pulp and paper industries in India: a case study
Case Stud Chem Environ Eng, 5 (2022), p. 100163
View PDF View article View in Scopus ↗ Google Scholar ↗

75 M. Mainardis, D. Goi
Pilot-UASB reactor tests for anaerobic valorisation of high-loaded liquid substrates in friulian mountain area
J Environ Chem Eng, 7 (5) (2019), p. 103348
View PDF View article View in Scopus ↗ Google Scholar ↗

76 N. Buyukkamaci, E. Koken

Economic evaluation of alternative wastewater treatment plant options for pulp and paper industry
Sci Total Environ, 408 (24) (2010), pp. 6070-6078
View PDF View article View in Scopus Google Scholar

77 A.K. Singh, R. Chandra
Pollutants released from the pulp paper industry: aquatic toxicity and their health hazards
Aquat Toxicol, 211 (2019), pp. 202-216
View PDF View article View in Scopus Google Scholar

78 T. Mandal, D. Dasgupta, S. Mandal, S. Datta
Treatment of leather industry wastewater by aerobic biological and Fenton oxidation process
J Hazard Mater, 180 (1–3) (2010), pp. 204-211
View PDF View article View in Scopus Google Scholar

79 R.E.A. Ghorab, A. Pugazhendi, M.T. Jamal, R.B. Jeyakumar, J.J. Godon, D.K. Mathew
Tannery wastewater treatment coupled with bioenergy production in upflow microbial fuel cell under saline condition
Environ Res, 212 (2022), p. 113304
View PDF View article View in Scopus Google Scholar

80 B. Chattopadhyay, S. Datta, A. Chatterjee, S.K. Mukhopadhyay
The environmental impact of waste chromium of tannery agglomerates in the East Calcutta wetland ecosystem
J Soc Leather Technol Chem, 84 (2) (2000), pp. 94-100
View in Scopus Google Scholar

81 K. Kolomaznik, M. Adamek, I. Andel, M. Uhlirova
Leather waste—potential threat to human health, and a new technology of its treatment
J Hazard Mater, 160 (2–3) (2008), pp. 514-520
View PDF View article View in Scopus Google Scholar

82 M. Nigam, P. Mishra, P. Kumar, S. Rajoriya, P. Pathak, S.R. Singh, *et al.*
Comprehensive technological assessment for different treatment methods of leather tannery wastewater
Environ Sci Pollut Res (2022), pp. 1-18, 10.1007/s11356-022-21259-x
Google Scholar

83 C. Saejung, P. Salasook
Recycling of sugar industry wastewater for single-cell protein production with supplemental carotenoids
Environ Technol, 41 (1) (2020), pp. 59-70
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

84 A.K. Chaurasia, P. Mondal
Enhancing biohydrogen production from sugar industry wastewater using Ni, Ni–Co and Ni–Co–P electrodeposits as cathodes in microbial electrolysis cells
Chemosphere, 286 (2022), p. 131728
View PDF View article View in Scopus ↗ Google Scholar ↗

85 J.P. Kushwaha
A review on sugar industry wastewater: sources, treatment technologies, and reuse
Desalin Water Treat, 53 (2) (2015), pp. 309-318
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

86 J.K. Friedel, T. Langer, C. Siebe, K. Stahr
Effects of long-term waste water irrigation on soil organic matter, soil microbial biomass and its activities in Central Mexico
Biol Fertil Soils, 31 (5) (2000), pp. 414-421
View in Scopus ↗ Google Scholar ↗

87 M.B. Vallejos, M.S. Marcos, C. Barrionuevo, N.L. Olivera
Salinity and N input drive prokaryotic diversity in soils irrigated with treated effluents from fish-processing industry
Appl Soil Ecol, 175 (2022), p. 104443
View PDF View article View in Scopus ↗ Google Scholar ↗

88 J. Ganoulis
Risk analysis of wastewater reuse in agriculture
Int J Recycl Org Waste Agric, 1 (1) (2012), pp. 1-9
Google Scholar ↗

89 K.P.M. Mosse, A.F. Patti, R.J. Smernik, E.W. Christen, T.R. Cavagnaro
Physicochemical and microbiological effects of long-and short-term winery wastewater application to soils
J Hazard Mater, 201 (2012), pp. 219-228
View PDF View article View in Scopus ↗ Google Scholar ↗

90 M.F. Jaramillo, I. Restrepo
Wastewater reuse in agriculture: a review about its limitations and benefits
Sustainability, 9 (10) (2017), p. 1734
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

91 R.M.A. Machado, R.P. Serralheiro
Soil salinity: effect on vegetable crop growth. Management practices to prevent and mitigate soil salinization
Horticulturae, 3 (2) (2017), p. 30
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

92 Y.A. Alemayehu, S.L. Asfaw, T.A. Terfie
Reusing urine and coffee processing wastewater as a nutrient source: effect on soil characteristics at optimum cabbage yield
Environ Technol Innov, 23 (2021), p. 101571
View PDF View article View in Scopus ↗ Google Scholar ↗

93 B.N. Gorfie, A.W. Tuhar, A. Shiberu Keraga, A.B. Woldeyohannes
Effect of brewery wastewater irrigation on soil characteristics and lettuce (Lactuca sativa) crop in Ethiopia
Agric Water Manag, 269 (2022), p. 107633
View PDF View article View in Scopus ↗ Google Scholar ↗

94 L. Tian, H. Sun, X. Dong, J. Wang, Y. Huang, S. Sun
Effects of swine wastewater irrigation on soil properties and accumulation of heavy metals and antibiotics
J Soil Sediment, 22 (3) (2022), pp. 889-904
CrossRef ↗ View in Scopus ↗ Google Scholar ↗

95 M.S. Aman, M. Jafari, M.K. Reihan, B. Motesharezadeh, S. Zare
Assessing the effect of industrial wastewater on soil properties and physiological and nutritional responses of Robinia pseudoacacia, Cercis siliquastrum and Caesalpinia gilliesii seedlings
J Environ Manage, 217 (2018), pp. 718-726
View PDF View article View in Scopus ↗ Google Scholar ↗

96 M. Adrover, E. Farrús, G. Moyà, J. Vadell
Chemical properties and biological activity in soils of Mallorca following twenty years of treated wastewater irrigation

J Environ Manage, 95 (2012), pp. S188-S192

View PDF View article View in Scopus ↗ Google Scholar ↗

97 A.K. Kargol, C. Cao, C.A. James, H.L. Gough
Wastewater reuse for tree irrigation: influence on rhizosphere microbial communities
Resour Environ Sustain, 9 (2022), p. 100063

View PDF View article View in Scopus ↗ Google Scholar ↗

98 D. Alvarez-Bernal, S.M. Contreras-Ramos, N. Trujillo-Tapia, V. Olalde-Portugal, J.T. Frías-Hernández, L. Dendooven
Effects of tanneries wastewater on chemical and biological soil characteristics
Appl Soil Ecol, 33 (3) (2006), pp. 269-277

View PDF View article View in Scopus ↗ Google Scholar ↗

99 P. Guedes, C. Martins, N. Couto, J. Silva, E.P. Mateus, A.B. Ribeiro, *et al.*
Irrigation of soil with reclaimed wastewater acts as a buffer of microbial taxonomic and functional biodiversity
Sci Total Environ, 802 (2022), p. 149671

View PDF View article View in Scopus ↗ Google Scholar ↗

100 F. Bastida, I.F. Torres, C. Romero-Trigueros, P. Baldrian, T. Větrovský, J.M. Bayona, *et al.*
Combined effects of reduced irrigation and water quality on the soil microbial community of a citrus orchard under semi-arid conditions
Soil Biol Biochem, 104 (2017), pp. 226-237

View PDF View article View in Scopus ↗ Google Scholar ↗

101 H.H. Kayikcioglu
Short-term effects of irrigation with treated domestic wastewater on microbiological activity of a Vertic xerofluvent soil under Mediterranean conditions
J Environ Manage, 102 (2012), pp. 108-114

View PDF View article View in Scopus ↗ Google Scholar ↗

102 F. Bastida, I.F. Torres, J. Abadía, C. Romero-Trigueros, A. Ruiz-Navarro, J.J. Alarcón, *et al.*
Comparing the impacts of drip irrigation by freshwater and reclaimed wastewater on the soil microbial community of two citrus species
Agric Water Manag, 203 (2018), pp. 53-62

View PDF View article View in Scopus ↗ Google Scholar ↗

103 A.M. Ibekwe, A. Gonzalez-Rubio, D.L. Suarez

Impact of treated wastewater for irrigation on soil microbial communities
Sci Total Environ, 622 (2018), pp. 1603-1610
View PDF View article View in Scopus ↗ Google Scholar ↗

104 B. Li, Y. Cao, X. Guan, Y. Li, Z. Hao, W. Hu, *et al.*
Microbial assessments of soil with a 40-year history of reclaimed wastewater irrigation
Sci Total Environ, 651 (2019), pp. 696-705
View PDF View article View in Scopus ↗ Google Scholar ↗

105 D.L. Xu, C.Y. Zhang, S.M. Qu, X. Ma, M.X. Gao
Characterization of microorganisms in the soils with sewage irrigations
Afr J Microbiol Res, 6 (44) (2012), pp. 7168-7175
Google Scholar ↗

Cited by (0)

View Abstract