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Process of Life Cycle Installation of Wastewater Treatment and up to Water Reuse

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ABSTRACT

The life cycle assessment (LCA) of the wastewater treatment plant (WWTP) has several categories in the resulting impact analysis. One of them is a wastewater treatment plant on campus or university. Various emissions from WWTP and their impact factors are analyzed using software and utilizing the Eco-inventory database. Recycled water from factories has a positive impact on the categories assessed. System treatment overrides the effects of recycled water in other types such as potential terrestrial eco-toxicity, global warming potential, particulate matter formation, fossil depletion potential, and others. However, untreated sewers' social effects and the environmental impact of compost generated by the system have not been thoroughly analyzed by a more holistic analysis. By using the LCA method, these results can be seen in Enim River's environment expressed in GWP units (global warming potential) and human health expressed in ODP units (Ozone Depletion Potential). Several studies have also been conducted on LCA, which has problems with wastewater. One of the most recent research analyses various wastewater treatment strategies, such as aerobic against anaerobic, chemical versus chemical, and biological combinations. The Enim River is found in the Indonesian province of South Sumatra. The Muara Enim Regency area is where the river flows from upstream to downstream. The Enim River is a child of the Lematang River. The GWP value had a GWP of 16% before being treated in wastewater, and it had a GWP of 41.3% after being treated with sewage. This result means that treating wastewater requires energy to do so. Before treatment, the MDP value was 10.4%, and after treatment was 20.4%. However, further action after the management of wastewater gives significant value to the assessment of GWP, MDP, and ODP. The three results provided a reduction value for the reuse of treated water and reused as water needs.

INTRODUCTION

Water is everyone's survival because it is their primary source of income (Maktabifard et al. 2018). As a result, in some dry places and semi-arid circumstances, it is increasingly vital to pay attention to water scarcity (Reznik et al. 2019, Paskett 1998). Water scarcity will result if rainfall drops (Lotfi et al. 2020), causing more serious difficulties. Water management will be required to meet the increased needs of a rapidly rising population and the complete depletion of water supplies (Glenn et al. 2009). Any new water sources to be regenerated or wastewater treatment techniques must be established and developed to provide an adequate water supply (Lahrich et al. 2021). There will be several essential options given the various treatment techniques that can be created whereby wastewater can be treated and used for other purposes, such as the need for gardening and bathing (Dingemans et al. 2020, Raschid-sally et al. 2001).

Wastewater treatment facilities are typically built by government departments (Hartley et al. 2019), although major organizations (Juan-García et al. 2017) or businesses can also build their WWTP (Waste Water Treatment Plant) (Raghuvanshi et al. 2017). The WWTP's mission is to purify untreated water from a wide range of sources, including households, offices, laboratories, and sanitation facilities so that it can be reused. There are both primary and secondary process steps at the WWTP (Abdel-Fatah 2018).

The water then flows into the aeration tank in the primary treatment process and then adds chemicals with high nutritional content, such as diammonium phosphate (DAP). For this condition, most of the microbial action is still in the air (Kheiri et al. 2013). Aerobic oxidation in the aeration tank causes organic matter degradation in microorganisms' pres-

ence (Wang et al. 2017). Furthermore, in the clarifier, sludge (Araromi et al. 2018) and water are separated outside. This is also part of the secondary processing process. The sludge is then collected and air-dried before storage and further use.

The semi-treated water then enters the chlorination tank, where disinfection is carried out. The disinfected water then passes through a double filter media to maintain the water condition for further storage (Zhu et al. 2012). Untreated sewers have social and environmental impacts (Dolar et al. 2019) if disposed of without proper treatment (Maktabifard et al. 2018). Wastewater treatment is also not an environmentally friendly process (Salem 2012) and even economically. Such processing will require a lot of energy and several forms of chemicals. An analysis will then be needed for the environmental benefits of water savings and ecological damage done to water treatment (Shakouri & Yazdi 2014, Zarei 2020).

Some wastewater treatment can be done physically, chemically, and biologically. Physical therapy is to remove suspended or levitated material from wastewater through gravity deposition. Meanwhile, chemical processing is by reducing the chemical content in sewage with the addition of chemicals. Deposition or filtering can physically separate the sediment as a result of the process. Finally, biological processing involves eliminating or removing pollutants using biological activity (microorganisms) in aerobic or anaerobic environments. In general, the physical processing units include bar screen, communicator, grit chamber, equalization, sedimentation, centrifugation, flocculation, and membrane filtration.

Whereas the residual pollutant discharge from the infiltration field drainage is subject to wastewater costs, the treated wastewater irrigation in the agricultural sector during the vegetation period is considered agricultural land treatment measures exempted from the cost of wastewater. This practice's cost reduction is estimated by calculating the wastewater's hypothetical cost (Diaz-Elsayed et al. 2019) operator. If the mixed-sludge irrigated wastewater was discharged directly into surface water bodies, the treatment facility would be compensated (Maaß & Grundmann 2016).

Another example of a unit process carried out in the United States, namely, the wastewater pasteurization (WP) process, is a disinfection technology that may have developed rapidly with cost and environmental advantages over traditional wastewater treatment processes (Sanciolo et al. 2020). It could exploit waste heat from on-site power plants by using biogas or gas from cities or community supplies to heat wastewater to inactivate associated Pasteurization technology has been widely used in the food industry for many years, but its application on a large scale to treat wastewater has only recently emerged. It has been demonstrated in the city of the Laguna Santa Rosa Wastewater Reclamation Plant, where validation testing was carried out as part of the California Department of Public Health (CDPH, now called the Drinking Water Division (DDW)) to review new technologies for treating wastewater for reuse and provision conditional consent water (Sanciolo et al. 2020).

There are advantages of using pasteurization to disinfect wastewater because it does not contain the harmful effects of unreacted disinfectant chemicals and the formation of hazardous disinfection byproducts known as a disinfectant byproduct (DBP). Chlorination and ozonation are commonly used for the disinfection of wastewater, and their extensive use has resulted in disinfectant byproducts (DBP) which are very dangerous. DBP from chlorination is harmful to humans and the environment (Chon et al. 2012) and causes acute, measurable toxicity effects even from low residual chlorine levels (Hamilton & Miller 2002).

The methodological framework used on the life cycle provided by the international standards organization (ISO) 14040 assesses the environmental impact of the wastewater treatment process on campus or university sites (Vedachalam 2012). The impact assessment carried out with a simple LCA is to visualize and analyze wastewater treatment processes' environmental impact. The Eco-invent data set software was used to model the movement of materials and energy (Raghuvanshi et al. 2017). After entering the input value into the LCA process, the Ecoinvent OpenLCA software can likewise produce good results.

A life cycle assessment (LCA) based on a thorough understanding of the true quantity of data received is used to conduct this analysis. LCA is a compilation and evaluation of the outputs and potential environmental consequences during a product's life cycle. LCA studies aid in determining the best method/technique from an ecological point of view. For LCA, four phases are required for the LCA study, namely definition of objectives and scope, analysis of life cycle inventory (LCI), life cycle impact assessment (LCIA), and interpretation (Raghuvanshi et al. 2017). LCA water treatment systems have found importance in recent literature due to their holistic approach. Several studies have also been conducted on LCA, which has problems with wastewater. One of the most recent studies compares different wastewater treatment techniques such as aerobic to anaerobic, chemical to chemical and biological combinations (Sode et al. 2013). Phosphorus recycling for agricultural land (because of its potential for fertilization) (Shamblen & Binder 1996) is more suitable to control to reduce the impact of depletion of fossil fuels and climate change compared to sludge incineration (Najafzadeh & Zeinolabedini 2018, Mannino et al. 2008).

Another method related to LCA WWTP carried out in China has revealed that the use of renewable energy (wind,

in this case) increasing the quality of waste will reduce environmental impact (Jain et al. 2020). This study highlights the importance of generating electricity from renewable sources to minimize fossil fuel depletion and pollutant emissions. A more refined approach is used to study LCA in WWTP by finding out characterization factors (CFs) for measuring pharmaceutical and personal care products (PPCP) in wastewater. Other studies have reported on a novel strategy for identifying the optimum WWTP process that tries to incorporate environmental concerns with LCA methodology and economic criteria.

MATERIALS AND METHODS

Unit Process Mechanism

The unit process mechanism is used to evaluate the environmental impact of process wastewater treatment at a specific place, such as a riverbank (Kristensen et al. 2018). For the LCA process, it is necessary to set goals or goals to be done. One of them is the boundary, namely gate to gate. What is meant by the gate to gate? Is it from processed wastewater to treated wastewater?

Data collection is carried out during operation over a period repeated. The operational input and quantity of wastewater inflows are measured at different times of the year. Specific processor maintenance-related data were obtained by conducting semi-structured interviews with staff working in the factory. Secondary data for modeling the flow of materials and energy are collected from the internet, datasheets, etc.

Research using tools to test the use of treated wastewater along the Enim River has a relationship with other available water resources taking into account their quantity and quality (Carey & Migliaccio 2009, Almanaseer et al. 2020), including the agronomic, environmental, and economic components (Rossum 2020). The study area's location is in the overall district of Muara Enim, consisting of 7.483 km², and the number of sections is 22, and the number of villages is 246, as shown in Fig. 1.

In this study's results, the operational input is measured in terms of electricity, and diesel is burned for power generation, urea and chlorine. Chlorine is used through a dosing pump to kill bacteria and other microbes remaining in treated water, but chlorine is a very toxic substance (Shakouri & Yazdi 2014)(Skander et al. 2015). The ReCiPe method (LCA Ecoinvent) provides results in three main endpoint categories: ecosystem quality, human health, and resources (Rathod et al. 2009). Ecosystem quality has nine sub-categories: agricultural land use, climate change, freshwater eco-toxicity, freshwater eutrophication, marine eco-toxicity, transformed natural land, terrestrial acidification, terrestrial eco-toxicity (Godoy et al. 2020), and city land occupation. There are six sub-categories regarding human health, namely climate change (human health) (Dingemans et al. 2020), human toxicity, ionizing radiation, ozone depletion, particulate matter photochemical oxidant formation. In the end, resources have two sub-categories, namely fossil depletion and metal depletion. The results of this study have 18 categories selected to show the environmental impacts of treated wastewater. The nine types determined by their abbreviations are climate change or global warming potential (GWP), freshwater eco-toxicity potential (FETP), freshwater eutrophication potential (FEP), human toxicity potential (HTP), metal depletion potential (MDP), ozone depletion potential (ODP), particulate matter formation (PMF), terrestrial eco-toxicity

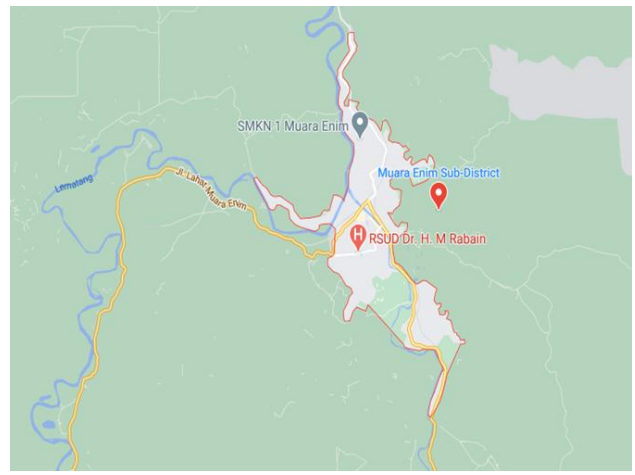


Fig. 1: Location of study area of Enim River in south Sumatra, Indonesia.

potential (TETP), and water depletion potential (WDP) as can be seen at Fig. 2 and Fig. 3.

RESULTS

Water Quality Before Treatment

Electricity and diesel are used to generate electricity, urea, and chlorine. The process of the energy source used affects the resulting emissions. These emissions cause damage to ambient air quality and ultimately to human health. It was found that energy requirements for the aeration tank, distribution treated water, collection tank, and dual media filters significantly affected the environment in the GWP, CC-HH, PMF, and FDP (Atiqah et al. 2014) categories (Lotfi et al. 2020). The actual yield values from the endpoint assessment of the treatment phase are tabulated in Table 1.

Water Quality after Treatment

The percentage distribution of the midpoint assessment result indicates that the wastewater treatment process stage has a nearly negligible effect on the environment than the other phases. Additionally, all steps show similar patterns of impact across all categories. As in the endpoint assessment, the treatment phases that impact water collection and sludge activation (Owusu-Twum & Sharara 2020, Brockmann et al. 2021) and redistribution are presented in Table 2.

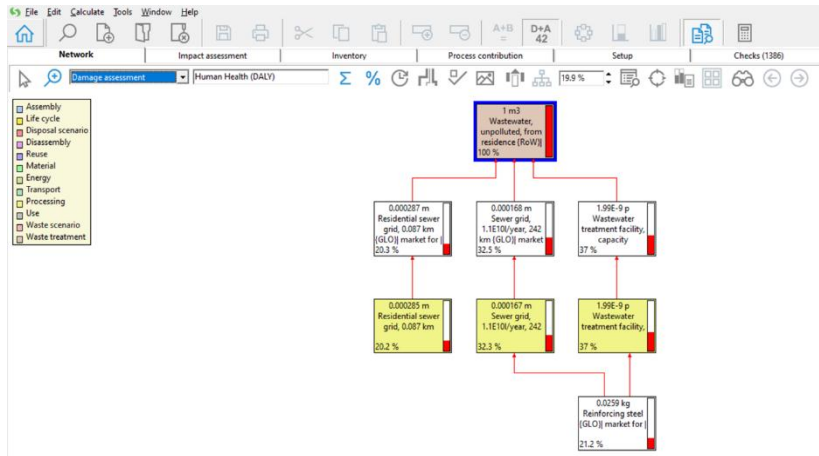


Fig. 2: Networking the normalization of the human health.

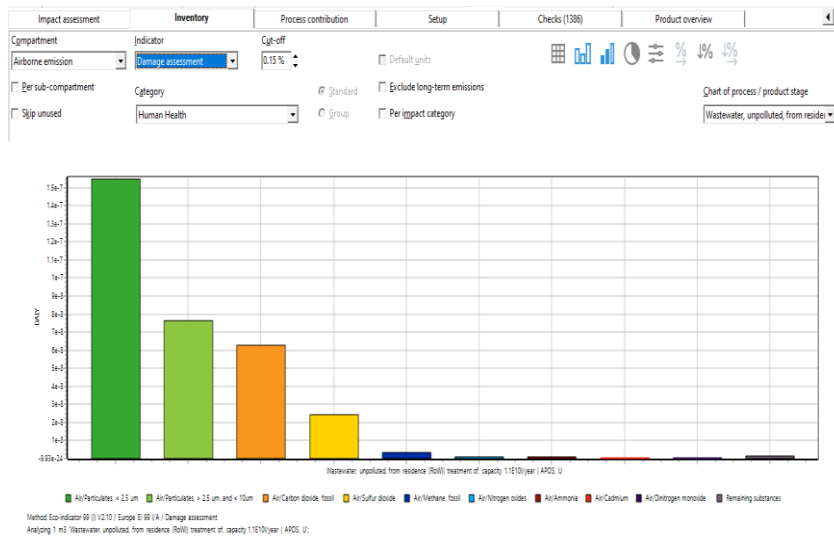


Fig. 3: Inventory airborne emissions damage emissions.

Table 1: The results of the study midpoint assessment.

Item	Ecosystem Quality (GWP)	Human Health (ODP/ Ozone Depletion Potential)	Resources (MDP/Metal Depletion Potential)
Water Collection (%)	16	26.4	10.4
Sludge Activation (%)	31.3	39.6	52
Treatment (%)	0.8	0.9	1
Purification (%)	12.4	9.9	10.4
Redistribution (%)	38.9	23.1	26

Table 2: Results of the study midpoint assessment.

Item	Ecosystem Quality (GWP)	Human Health (ODP/ Ozone Depletion Potential)	Resources (MDP/Metal Depletion Potential)
Water Collection (%)	41.3	35.4	20.4
Sludge Activation (%)	16	30.6	40
Treatment (%)	0.8	0.9	3
Purification (%)	10.4	10.9	11.4
Redistribution (%)	30.9	22.1	25

It was found that the energy requirements for the aeration tank, distribution treated water, collection tank, and dual media filter significantly affected the environment in the GWP, CC-HH, PMF, and FDP categories.

The first condition is if the wastewater is treated and its impact on the environment (Wagner 2005) and further assessed. The second condition is a consequence of wastewater treatment, and the treated water is used for irrigation purposes.

The effect of an equivalent amount of fresh water is then saved. The third condition depicts the consequences of not reusing purified water. This may be seen in the treatment outcomes of irrigation water, which have dramatically reduced environmental consequences across the board (Table 3). Fig. 4 and Fig. 5 below presents an impact assessment covering climate change, ozone layer depletion, acidification, and land use. The unit is stated as DALY (Disability Adjusted Life Year).

DISCUSSION

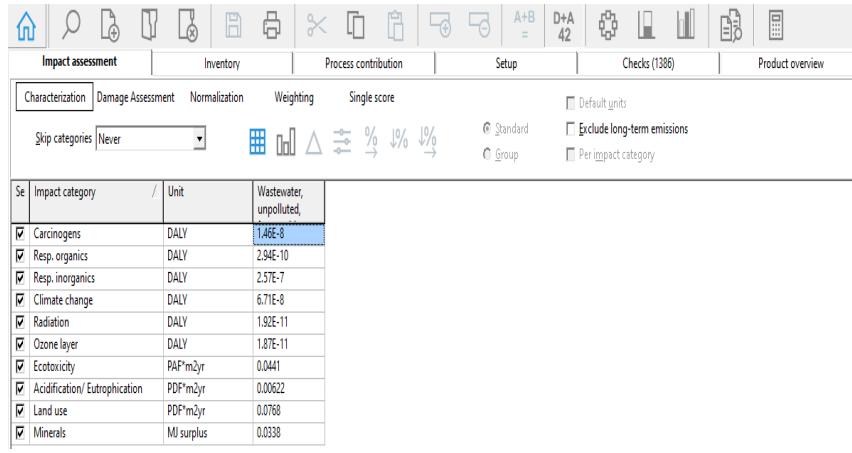
The results of a review of articles from research conducted by (Raghuvanshi et al. 2017) provide an analysis that when processing industrial wastewater requires electrical energy in its processing. The most significant consideration is the energy source process used, which affects the emissions produced (Ramírez-Melgarejo et al. 2019). These emissions cause damage to ambient air quality and ultimately to human health. The impact of the FDP is due to the significant amount of fossil fuels required for energy. These results can be seen in the environment expressed in GWP units (global warming potential) and human health expressed in units of ODP (Ozone Depletion Potential). Before treatment, the MDP value was 10.4%, and after treatment was 20.4%. This result means that treating wastewater requires energy to do so. This energy in the form of energy requirements for the aeration tank, distribution treated water, collection tank, and dual filter media significantly affects the environment in the GWP, ODP and PMF categories.

Table 3: Results of impact savings through reuse of treated water.

Item	Ecosystem Quality (GWP)	Human Health (ODP/ Ozone Depletion Potential)	Resources (MDP/Metal Depletion Potential)
Water Collection (%)	11.4	53.1	35.5
Sludge Activation (%)	41.3	29.6	32
Treatment (%)	0.8	0.9	1
Purification (%)	19.4	9.9	10.4
Redistribution (%)	26.9	6.5	21

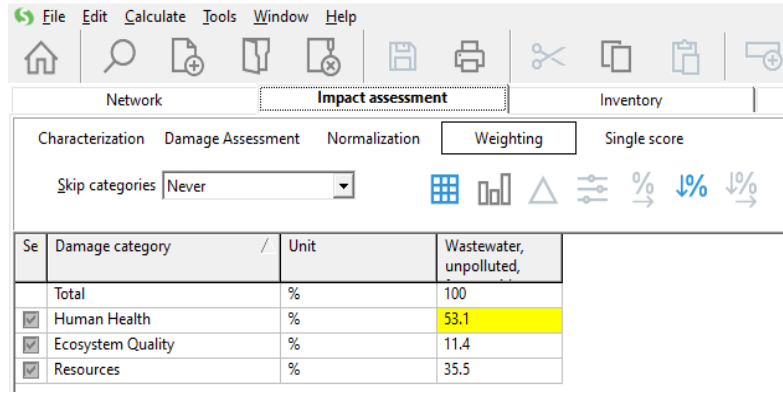
Likewise, the results on MDP and ODP were given before and after treating the wastewater produced. Before treatment in wastewater, the GWP value gave a GWP of 16%, and after being treated with sewage, it gave a GWP of 41.3%. However, subsequent action following wastewater management adds significant value to the GWP, MDP, and ODP assessments (Enström et al. 2019). The three outcomes showed a reduction in the cost of reusing treated water for other purposes. Functional water, on the other hand, cannot be utilized as drinking water. Watering plants (gardening) or irrigation systems for rice fields are the following applications.

The most important thing from the article review analysis that I have done is on the sludge produced from wastewater. The most important thing is that it has not considered sludge for fields and can be used as a fertilizer substitute. Studies like these can guide authorities and governments to optimize process parameters to reduce environmental impacts. Although in wastewater management, it is for the reuse of water for the purposes it is intended for, and it is necessary to consider environmental protection. At the time of wastewater management will require electrical energy needs to do it. Electrical power is whether using fossil energy sources or using electrical energy from renewable energy (An et al. 2019). Suppose the use of electricity still uses fossil energy, of course. In that case, it will impact the potential for global warming or the potential for depletion of the ozone layer. Therefore it provides an LCA (life cycle assessment) analysis in the process. This is very important because it has been explained at the beginning of the introduction in this review article that LCA analysis will require a goal or goals to be achieved. When treating wastewater, the limitations will yield the best outcomes. If the limit is to reuse water, it must be verified that it has no substantial environmental impact during the processing process, either through emissions or later environmental improvements.



Se	Impact category	Unit	Wastewater, unpolluted,
☑	Carcinogens	DALY	1.46E-8
☑	Resp. organics	DALY	2.94E-10
☑	Resp. inorganics	DALY	2.57E-7
☑	Climate change	DALY	6.71E-8
☑	Radiation	DALY	1.92E-11
☑	Ozone layer	DALY	1.87E-11
☑	Ecotoxicity	PAF*m2yr	0.0441
☑	Acidification/ Eutrophication	PDF*m2yr	0.00622
☑	Land use	PDF*m2yr	0.0768
☑	Minerals	MJ surplus	0.0338

Fig. 4: Impact assessment wastewater unpolluted.



Se	Damage category	Unit	Wastewater, unpolluted,
	Total	%	100
☑	Human Health	%	53.1
☑	Ecosystem Quality	%	11.4
☑	Resources	%	35.5

Fig. 5: Weighting of Impact Assessment

CONCLUSION

This paper presents an assessment of wastewater treatment along a watershed. The results obtained have provided information that the electricity required to carry out the entire treatment process (water collection, sludge activation, treatment, purification, and redistribution) has the highest impact across all category assessments. Moreover, the use of water for irrigation purposes reduces the impact caused by the treatment process to a large extent and ultimately reduces the environmental burden. It should be noted that the global warming potential increases with treatment, but the water depletion potential decreases. The research helps decision-makers to make informed decisions to choose between medicine or no treatment (no reuse) of wastewater. This may be observed in the results of MDP and ODP tests performed before and after the effluent was treated. The GWP value had a GWP of 16 per cent before being treated in wastewater, and it had a GWP of 41.3 per cent after being treated with sewage. The analysis in this work is restricted to the system boundaries (gate to gate) and research considerations.

This study has not considered sludge for fields and can be used as a substitute for fertilizer. Studies such as these can guide authorities and governments to optimize process parameters to reduce environmental impacts. This wastewater treatment model can be continued to assess the ecological impact in larger areas such as large or small cities, where the supply network and redistribution of wastewater also play an essential role in energy consumption. Therefore it will be interesting to look at the negative environmental impacts with the combined treatment and positive effects of reusing treated water and using sludge as compost for gardening or agriculture.

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REFERENCES

Abdel-Fatah, M.A. 2018. Nanofiltration systems and applications in wastewater treatment: Review article. Ain Shams Eng., 9(4): 3077-3092. https://doi.org/10.1016/j.asej.2018.08.001.

Almanaseer, N., Muna, H. and Raha, A. 2020. Hydrological and environmental impact of wastewater treatment and reuse on Zarqa river basin in Jordan. Environ. MDPI, 7(2): 14. https://doi.org/10.3390/environments7020014.

An, Y., Zhang, L. and Adom, P.K. 2019. Economics of wastewater management in China's industry. Environment and Development Economics, 24 (5): 457-78. https://doi.org/10.1017/S1355770X19000202.

Araromi, D.O., Majekodunmi, O.T., Adeniran, J.A. and Salawudeen, T.O. 2018. Modeling of an activated sludge process for effluent prediction-a comparative study using ANFIS and GLM regression. Environmental Monitoring and Assessment, 190(9): 1-17.

Atiqah, N., Abustan, I., Mahyun A.W. and Rose, F.M. 2014. Water quality changes due to effect of Arowana aquaculture activities at Bukit Merah. Advances in Environmental Biology, 8(22): 30-34.

Brockmann, D., Yves, G., Chul, P., Kim, M., Arnaud, H. and Jérôme, H. 2021. Wastewater treatment using an anoxygenic photogravure-based process has a lower environmental impact than conventional activated sludge processes. Bioresour. Technol., 9: 319. https://doi.org/10.1016/j.biortech.2020.124204.

Carey, R.O. and Migliaccio, K.W. 2009. Contribution of wastewater treatment plant effluents to nutrient dynamics in aquatic systems. Environ. Manag., 44(2): 205-217. https://doi.org/10.1007/s00267-009-9309-5.

Chon, H.S., Dieudonné, G.O. and Nikolaos, V. 2012. Assessing the relative contribution of wastewater treatment plants to levels of metals in receiving waters for catchment management. Water Air Soil Pollut., 223(7): 3987-4006. https://doi.org/10.1007/s11270-012-1166-9.

Diaz-Elsayed, N., Nader, R., Tianjiao, G., Shima, M. and Qiong, Z. 2019. Wastewater-based resource recovery technologies across scale: A review. Resour. Conserv. Recycl., 145: 94-112. https://doi.org/10.1016/j.resconrec.2018.12.035.

Dingemans, M.M., Smeets, P.W., Medema, G., Frijns, J., Raat, K.J., van Wezel, A.P. and Bartholomeus, R.P., 2020. Responsible water reuse needs an interdisciplinary approach to balance risks and benefits. Water, 12(5), p.1264. Doi: 10.3390/w12051264.

Dolar, D.M., Racar, S. and Košutić K. 2019. Municipal wastewater reclamation and water reuse for irrigation by membrane processes. Chem. Biochem. Eng. Quart., 33(3): 417-425. https://doi.org/10.15255/CABEQ.2018/1571.

Enström, A., Timo, H., Adrian, S., Michael, G. and Kuan, Y.L. 2019. Introducing a new GHG emission calculation approach for alternative methane reduction measures in the wastewater treatment of a palm oil mill. Environ. Develop. Sustain., 21(6): 3065-3076. https://doi.org/10.1007/s10668-018-0181-4.

Glenn, E.P., Casey, M., Vanda, G., Pamela, L.N., Fiona, J. and Janick, A. 2009. Deficit irrigation of a landscape halophyte for reuse of saline wastewater in a desert city. Landsc. Urban Plan., 89(3-4): 57-64. https://doi.org/10.1016/j.landurbplan.2008.10.008.

Godoy, L., Gabriel, G., Abrahão, B.R., Mônica, R.G., Silvana, D.D. and Lucas, B.G. 2020. Production of supplementary cementitious material as a sustainable management strategy for water treatment sludge waste. Case Stud. Constr. Mater., 12: 329. https://doi.org/10.1016/j.cscm.2020.e00329.

Hamilton, A.P.A. and Miller, T.L. 2002. Lessons from the national water-quality assessment : A decade of intensive water-quality studies indicates that reducing diffuse nonpoint water contamination requires new tools and a holistic management approach. J. Soil Water Conserv., 57(1): 16A-21A

Hartley, K., Cecilia, T. and Asit, K.B. 2019. A formal model concerning policy strategies to build public acceptance of potable water reuse. J. Environ. Manag., 250: 109505. https://doi.org/10.1016/j.jenvman.2019.109505.

Jain, R., Harshita, N., Megha, M., Anushree, M. and Upain, K.A. 2020. Towards green thermal power plants with blowdown water reuse and simultaneous biogenic nanostructures recovery from waste. Resour. Conserv. Recycl., 11: 105283. https://doi.org/10.1016/j.resconrec.2020.105283.

Juan-García, P., Butler, D., Comas, J., Darch, G., Sweetapple, A. and Corominas, L. 2017. Resilience theory incorporated into urban wastewater systems management. Water Res., 115: 149-61. https://doi.org/10.1016/j.watres.2017.02.047.

Kheiri, R., Naser, H. and Mehrouz D. 2013. Efficacy evaluation of four different culture and PCR-based methods of Escherichia coli detection in water samples. Advances in Environmental Biology, 7(9): 2689-2694.

Kristensen, E., Mikkel, M., Philippe Massicotte, O., Pedersen, S., Markager, R. and Theis, K. 2018. Catchment tracers reveal discharge, recharge, and sources of groundwater-borne pollutants in a novel lake modeling approach. Biogeosciences, 15(4): 1203-1216. https://doi.org/10.5194/bg-15-1203-2018.

Lahrich, S.F., Laghrib, A., Farahi, M., Bakasse, S., Saqrane, K. and M.A. and Mhammed, E. 2021. Review on the contamination of wastewater by COVID-19 virus: Impact and treatment. Sci. Total Environ., 751: 142325. https://doi.org/10.1016/j.scitotenv.2020.142325.

Lotfi, K., Hossein, B., Isa Ebtehaj, R., Ali Akbar, Z. and Bahram, G. 2020. A novel stochastic wastewater quality modeling based on fuzzy techniques. J. Environ. Health Sci. Eng., 20: 530 https://doi.org/10.1007/s40201-020-00530-8.

Maaß, O. and Grundmann, P. 2016. Added-value from linking the value chains of wastewater treatment, crop production, and bioenergy production: A case study on reusing wastewater and sludge in crop production in Braunschweig (Germany). Resour. Conserv. Recycl., 107: 195-211. https://doi.org/10.1016/j.resconrec.2016.01.002.

Maktabifard, M., Ewa, Z. and Jacek, M. 2018. Achieving energy neutrality in wastewater treatment plants through energy savings and enhancing renewable energy production. Rev. Environ. Sci. Biotechnol., 17: 540. https://doi.org/10.1007/s11157-018-9478-x.

Mannino, I., Daniel, F., Enrico, P., Laura, F., Erika, M. and Gabriele, Z. 2008. A cost-effectiveness analysis of seminatural wetlands and activated sludge wastewater treatment systems. Environ. Manag., 41(1): 118-29. https://doi.org/10.1007/s00267-007-9001-9006.

Najafzadeh, M. and Zeinolabedini, M. 2018. Derivation of optimal equations for prediction of sewage sludge quantity using wavelet conjunction models: An environmental assessment. Environ. Sci. Pollut. Res., 25(23): 22931-22943. https://doi.org/10.1007/s11356-018-1975-5.

Owusu-Twum, M.Y. and Sharara, M.A. 2020. Sludge management in anaerobic swine lagoons: A review. J. Environ. Manag., 271: 110949. https://doi.org/10.1016/j.jenvman.2020.110949.

Paskett, C.J. 1998. Refugees and land use: the need for change is a growing problem. J. Soil Water Conserv., 53(1): 57-58.

Raghuvanshi, S., Vikrant, B., Chelikani, S. and Sangwan, K.S. 2017. Wastewater treatment plant life cycle assessment: Treatment process to reuse of water. Procedia CIRP, 61: 761-66. https://doi.org/10.1016/j.procir.2016.11.170.

Ramírez-Melgarejo, M., Santiago, G.D. and Leonor, P. G. 2019. Evaluation of N 2 O emissions in wastewater treatment systems: A comparative analysis of emission between case studies of developed and developing countries. Water Air Soil Pollut., 230(2): 4086. https://doi.org/10.1007/s11270-019-4086-0.

Raschid-Sally, L., Wim, V.D. H. and Mala, R. 2001. Wastewater reuse in agriculture in Vietnam : Water Manag. Environ. Human Health Aspects, 45: 1106.

Rathod, P.H., Jyotindra, C., Patel, M.R.S. and Amit J.J. 2009. Recycling gamma-irradiated sewage sludge as fertilizer: A case study using onion (Alium cepa). Appl. Soil Ecol., 41(2): 223-33. https://doi.org/10.1016/j.apsoil.2008.11.001.

Reznik, A., Ariel, D. and Francesc, H.S. 2019. Treated wastewater reuse: An efficient and sustainable solution for water resource scarcity. Environ. Resour. Econ., 74: 383. https://doi.org/10.1007/s10640-019-00383-2.

Rossum, T.V. 2020. Water reuse and recycling in Canada: History, current situation, and future perspectives. Water Cycl., 4 : 98-103. https://doi.org/10.1016/j.watcyc.2020.07.001.

Salem, S.S. Al. 2012. Wastewater reuse for agricultulture: Regional health perspective . Eastern Mediterranean Health Journal, 12(3): 446-458.

Sanciolo, P., Paul, M., Justin, L., Greg, R., Andrew, S., Nicola, F., Judy, B. and Stephen, G. 2020. Water effectiveness and energy requirements of pasteurization for the treatment of unfiltered secondary effluent from a municipal wastewater treatment plant. Water, 12(8): 2100.

Shakouri, B. and Yazdi, S.K. 2014. Environment and water pollution. Advances in Environmental Biology, 8(5): 1328-1332.

Shamblen, R.G. and Binder, D.M. 1996. The effect of the watershed, reservoir volume, and rainfall on nitrate levels in surface drinking water supplies. J. Soil Water Conserv., 51(6): 457-461.

Skander, K., Dahel, A., Djebbari, N., Barour, C. and Bensouilah, M.. 2015. Environmental parameters influence on the bacteriological water quality of the Algerian North East Coast. Advances in Environmental Biology, 9(18): 180-189.

Sode, S., Annette Bruhn, T., Balsby, J.S., Martin, M.L., Annemarie, G. and Michael, B.R. 2013. Bioremediation of reject water from anaerobically digested wastewater sludge with Macroalgae (Ulva Lactuca, Chlorophyta). Bioresour. Technol., 146: 426-435. https://doi.org/10.1016/j.biortech.2013.06.062.

Vedachalam, S. 2012. Water_resources_and_wastewater reuse: perception of students at the Ohio State University Campus. Ohio Journal of Science. (110) 5: 104-113.

Wagner, Mimi M. 2005. Watershed-scale social assessment. Journal of Soil and Water Conservation, 60(4): 177-86.

Wang, Jing Han, Tian Yuan Zhang, Guo Hua Dao, Xue Qiao Xu, Xiao Xiong Wang, and Hong Ying Hu. 2017. Microalgae-based advanced municipal wastewater treatment for reuse in water bodies. Applied Microbiology and Biotechnology, 101 (7): 2659-75. https://doi.org/10.1007/s00253-017-8184-x.

Zarei, M. 2020. Wastewater resources management for energy recovery from a circular economy perspective. Water-Energy Nex., 3: 170-185. https://doi.org/10.1016/j.wen.2020.11.001.

Zhu, H., Huang, G.H. and Guo, P. 2012. SIFNP: Simulation-based interval-fuzzy nonlinear programming for seasonal planning of stream water quality management. Water Air Soil Pollut., 223(5): 2051-2072. https://doi.org/10.1007/s11270-011-1004-5.