International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Pharmaceutical and Hospital Wastewater Treatment by Subsurface Constructed Wetland: Current Scenario

Anurag Kumar

Central University of Jharkhand, Ranchi, India
Email: *aru771[at]yahoo.com*

Abstract: ***Constructed wetland systems (CWs) are the best natural base for wastewater treatment, having the advantage of treating domestic, agricultural, mining, and industrial waste water together with emerging organic contaminants (EOC). At present, there can be an increasing load on hospitals and constant challenges to supply vacations from pharmaceutical companies due to Corona pandemic waves. This leads to excessive EOCs such as pharmaceutical products (PhCsP), immunity booster products (IBP), the production of steroidal hormones (SH), and personal care products (PCP). The horizontal subsurface flow - constructed wetland (HSFCW) is used as a secondary treatment unit for wastewater. Pharmaceutical waste water by HFCW as average 98% of the removal efficiency reported by the researchers. In this paper, the treatment performance will be evaluated by biological oxygen demand (BOD), Chemical Oxygen Demand (COD), total solids (TS), Total Nitrogen (TN), total phosphorus (TP), pharma active compounds (PhACs), pathogens, etc. There are many treatment techniques, such as ultraviolet treatment (UVT), Ozone Treatment (OT), anaerobic digestion, trickling filter, biosolids, activated sludge method, conventional activated sludge (CAS), and membrane bioreactors (MBR) are available for wastewater treatment. Due to direct disposal in the environment, it is very important to shorten the various techniques for the treatment of WW.***

Keywords: Pharmaceutical, Hospital, wastewater, Treatment, Wetland

1. Introduction

According to published data, developing and non - developed countries generate 200–400 L of HWW per bed per day [1, 2, 3, 4, 5]. Germany 2258, Portugal 892, USA 968, Brazil 687, Spain 572, and India 156 - 480 L/patient / day generated [6]. The amount of waste generated depends on the number of beds occupied by the hospital at the time. Due to the large amount of wastewater generated from hospitals and pharmaceutical companies, its treatment is a challenge for environmental engineers [7]. These challenges also increased when HWW and PWW were observed in groundwater [8]. The amount of hospital wastewater contains much more types of pollutants, including phenolic compounds (floor cleaner), liquid medical waste, kitchen oil, laundry, in - house wastewater, and health care technical facilities [11]. In most countries, hospitals and pharmaceutical companies leave wastewater in surface water bodies such as ponds, rivers, lakes, and streams, with or without primary treatment [11–12]. CWs are low - cost, nature - based treatment systems.

Types of Pollutent in Pharmaceutical/ Hospital Waste water

The pharmaceutical micropollutants include atenolol, bezafibrate, carbamazepine, clarythromycin, ciprofloxacin, cyclophosphamide, diclofenac, erythromycin, ketoprofen, lidocaine, metoprolol, propranolol, n - acetyl sulfamethoxazole, and sulfamethoxazole. Corrosion inhibitor pesticides and herbicide micropollutants are benzotriazole, carbendazim, deet, diuron, isoproturon, terbutryn, mecoprop, tris (2 - chloroisopropyl) phosphate, tolyltriazole, and glyphosate AMPA (aminomethylphosphonic acid) [9]. Researchers reported that durges metabolites in effluents in WWTP. Caffeine, Clofibric acid, Cotinine, Cyclophosphamide, Diclofenac, Fenoprofen, Fluoxetine, Gemfibrozil, Ibuprofen, Indomethacin, Ketoprofen, Naproxen, Norfluoxetine, and Trimethoprim are the pharmaceutical compounds found in WW effluents [10].

Types of Constructed Wetland

There are two types of wetlands: natural wetland and constructed wetland (CW). The CW was further classified into 3 categories: 1. wetland constructed with vertical flow 2. Subsurface flow - constructed wetland 3. Hybrid - flow - constructed wetland. The main part of wetland is the substratum and vegetation's [5–13].

Plants Used in Horizontal Flow Constructed Wetland

The selection of plants in HFCW depends on local conditions, that is, climate, temperature, local availability of plants, and types of pollutants [15]. Scirpus, Typha, Carex, Swamp Foxtail Grass P. australis, T. latifolia, P. hydropiper, A. sessilis, C. esculenta, and P. stratoites, common rush, common reed, club - rush, cattail, common water plantain, Reed canary grass, Meadowsweet, Yellow Flag, Compact Rush, and Canna indica are used for wastewater treatment in CWs at the base of the soil [16]. Typha angustifolia, Phragmites australis, Hydrocottle spp., Typha latifolia, Juncus effuses, Ryegrass, Dryan, Waseyutaka, Salix atrocinerea, Lolium, Juncus effuses, and Paspalum spp. are some plants used for pharmaceutical and hospital wastewater treatment in HFCW [17].

Machanisum of Constructed Wet Land

CWs remove organic impurities, solids, phosphorus compounds, nitrogen compounds, pathogens, and heavy metals (EPA) as a result of various processes. For instance, sedimentation, filtration, and absorption all remove different types of solids. An organic impurity (BOD, COD) removes microbial, aerobic, and anaerobic action. According to the EPA, nitrogen available in the form of organic nitrogen, ammonia (NH_3) or ammonium (NH_4^+), nitrate ($NO_3^{-)}$ and nitrite ($NO_2^{-)}$ are available in sludge and wastewater. Vitalization, plant uptake, adsorption, ammonification, nitrification, or denitrification are some of the processes that remove nitrogen from the environment (USEPA). In the literature, mechanisms of relation between plant tissue and subsurface materials are available. Phosphorus is available in the form of orthophosphate, polyphosphate, and organic phosphate in wastewater and sludge, which is removed by plant uptake, adsorption, precipitation, and complexation [14]. The removal of heavy metals or trace elements by CWs occurs through the action of plant uptake, oxidation, sedimentation, adsorption, filtration, cation exchange, and complexation [15]. Pathogen removal occurs through sedimentation, natural die - off, UV degradation, and adsorption. The working nature of plants includes phytostabilization (reduction of heavy metals in the soil) in the root, phytodegradation (breakdown of contaminants by effective enzymes) in the trunk, phytoaccumulation or phytoextration (plants and algae remove high - density heavy metals from soil, sediments, and wastewater), and phytovolatiozation (release of contaminants in the atmosphere) [18].

Pharmaceutical and Hospital wastewater treatment by subsurface constructed wetland

The constructed wetlands are becoming increasingly popular for wastewater treatment. Although a constructed wetland requires a large land area, its operation is very cheap. The various features of CWs are shown in table 1. All the contents in Table 1 are for treatment of pharmaceutical and hospital wastewater. This detail is based in full scale or pilot scale treatment unit. Primary treatment is necessary for the treatment of HWW/ PWW.

Table 1: Performance evaluation of SFCW for various parameters

Country	Flow	HRT	Media	Plants	Removal %				Reference
					BOD	COD	TN	TP	
India	10 m^3/d	7 dats	Sand and gravel	Phragmites australis	96	94		79	[19]
Southern Ethiopia	237.6 liters/day	4 days	Broken Brick	Papyrus	80	76	95	84	[20]
Southern Ethiopia	237.6 liters/day	4 days	Broken Brick	Typha	95	61	95	87	[20]
Southern Ethiopia	237.6 liters/day	4 days	Broken Brick	No Plants	83	76.2	67	50	[20]
Southern Ethiopia	237.6 liters/day	4 days	Gravel	Sugar cane	96	67	-	-	[20]
Southern Ethiopia	237.6 liters/day	4 days	Gravel	Typha	96	61	75	55	[20]
Southern Ethiopia	237.6 liters/day	4 days	Gravel	Papyrus	93	68	69	52	[20]
Southern Ethiopia	237.6 liters/day	4 days	Gravel	Bulrush	93	70	70	50	[20]
Southern Ethiopia	237.6 liters/day	4 days	Gravel	No Plants	87	76.2	47	30	[20]
Nepal	20liters/day	1 day	Gravel and Sand	Phragmites karka	98	95	89	69	[21]
Iran	220 liters/day	4 days	Sand Gravel and Clay	Vativer	88	91	88	99	[22]
Iran	220 liters/day	4 days	Sand Gravel and Clay	Reed	82	81	75	99	[22]

(Reference 20 has been considered for dry season)

Table 1 shows by what percentage a lot of wastewater pollution can be reduced by wetland.

Table 2: Range of parameters

S. No.	Parameters	Unit	HWW	MWW	Reference
1	BOD_5	mg/L	200 - 300	150 - 400	[24]
2	COD	mg/L	120 - 500	50 - 170	
3	TSS	mg/L	150 - 160	50 - 60	
4	TN	mg/L	5 - 80	20 - 70	
5	TP	mg/L	0.2 - 13	4 - 10	
6	Chlorides	mg/L	65 - 360	30 - 90	
7	E. Coli	MPN/100 ml	10^3 - 10^6	10^6 – 10^7	
8	Fecal Coliform	MPN/100 ml	10^3 - 10^7	10^{6} - 10^8	
9	Total Coliform	MPN/ 100 ml	10^{5} - 10^8	10^{7} - 10^8	

The average 90% removal of TSS, BOD and COD is possible for HWW [20 - 29]. The pharmaceutical compound in wastewater can be effectively removed by CW under the redox condition of anaerobic and aerobic soil [23]. Soil - based CWs are more effective to remove the pollutants [25 - 30].

2. Conclusion

All living things, including animals, plants, and people, are seriously threatened by the presence of pharmaceutical and hospital wastewater in the environment. The majority of current research focuses on the overall elimination of pharmaceutical and hospital wastewater utilising Constructed wetlands. Additional studies are required to determine the effectiveness of various bacteria with regard to climate and temperature, to incorporate anaerobic setup to complete the denitrification - nitrification process, and to examine the impact of pharmaceuticals from hospitals on treatment through CWs effectiveness.

References

[1] Mishra K., Sharma A., Ayub S. A study: biomedical waste management in India. *IOSR J. Environ. Sci.*

*Toxicol. Food Technol.*2016; 10 (5): 64–67. doi: 10.9790/2402 - 1005026467.

[2] Al Aukidy M., Al Chalabi S., Verlicchi P. Hospital wastewater treatments adopted in Asia, Africa, and Australia. *Hdb Environ. Chem.*2018: 171–188. doi: 10.1007/698_2017_5.

[3] Al Aukidy M., Verlicchi P., Voulvoulis N. A framework for the assessment of the environmental risk posed by pharmaceuticals originating from hospital effluents. *Sci. Total Environ.*2014; 493: 54–64. doi: 10.1016/j. scitotenv.2014.05.128.

[4] Emmanuel E., Gisèle M., Perrodin Y. Groundwater contamination by microbiological and chemical substances released from hospital wastewater: Health risk assessment for drinking water consumers. *Environ. Int.*2009; 35 (4): 718–726. doi: 10.1016/j. jhazmat.2004.08.032.

[5] Carraro E., Bonetta S., Bertino C., Lorenzi E., Bonetta S., Gilli G. Hospital effluents management : chemical, physical, microbiological risks and legislation in different countries. *J. Environ. Manage.*2016; 168: 185–199. doi: 10.1016/j. jenvman.2015.11.021

[6] Majumder A., Gupta, A. K., Ghosal P. S., Verma M. “A review on hospital wastewater treatment: A special emphasis on occurrence and removal of pharmaceutically active compounds, resistant microorganisms, and SARS - CoV - 2”. J Environ Chem Eng.2021 Apr; 9 (2): 104812. Published online 2020 Nov 22. doi: 10.1016/j. jece.2020.104812.

[7] Kumari A., Maurya N. S., Tiwari B. *Curr. Dev. Biotechnol. Bioeng*. Elsevier; 2020. Hospital wastewater treatment scenario around the globe; pp.549–570.

[8] John R. White J. R., Belmont M. A., Metcalfe C. D. “Pharmaceutical Compounds in Wastewater: Wetland Treatment as a Potential Solution” TheScientificWorldJOURNAL (2006) 6, 1731–1736

[9] Brunhoferova H., Venditti S., Schlienz M., Hansen J., “Removal of 27 micropollutants by selected wetland macrophytes in hydroponic conditions” Chemosphere 281 (2021) 130980.

[10] Matamoros, V., Garcia, J., and Bayona, J. M. (2005) Behavior of selected pharmaceuticals in subsurface flow constructed wetlands: a pilot - scale study. *Environ. Sci. Technol.*3**9**, 5449–5454.

[11] Majumder A., Gupta A. K., Ghosal P. S., Verma M., A review on hospital wastewater treatment: A special emphasis on occurrence and removal of pharmaceutically active compounds, resistant microorganisms, and SARS - CoV - 2. Journal of Environmental Chemical Engineering. S2213 - 3437 (20) 31161 - 1

[12] Patel M., Kumar R., Kishor K., Mlsna T., Pittman C. U., Mohan D., Pharmaceuticals of Emerging Concern in Aquatic Systems: Chemistry, Occurrence, Effects, and Removal Methods. Chem. Rev.2019, 3510 - 3673.

[13] EPA. (1988). —Design Manual - Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment.

[14] Vymazal J., Brix H., Perfler R., Removal mechanisms and types of constructed wetlands. Book chapter January 1998.

[15] Swarnakar, A. K., Bajpai, S., & Ahmad, I. (2021). Geo Physicochemical Properties for Soil BaseSubsurface Constructed Wetland System. *AIJR Proceedings*, 228 - 233. https: //doi. org/10.21467/proceedings.112.28

[16] Jethwa K., Bajpai S., Choudhary P. K., Swarnakar A. K., (2016). Wastewater Nutrient Removal Through Phytoremidiation: A Review: 49th Annual Convention of IWWA on "Smart Water Management"January 19 - 21, 2017

[17] Y. li, G. Zhu, W. J. Ng., S. K. Tan, A review on removing pharmaceutical contaminants from wastewater byconstructed wetlands: Design, performance and mechanism. Sci. TotalEnviron.468–469 (2014) 908–932.

[18] Srivastava J, Gupta A, Chandra H. Managing water quality with aquatic macrophytes. Rev Environ Sci Biotechnol.2008; 7: 255–266

[19] N. A. Khan, R. El Morabet, R. A. Khan, S. Ahmed, A. Dhingra, M. Alsubih, A. R. Khan, Horizontal sub surface flow Constructed Wetlands coupled with tuben settler for hospital wastewater treatment, J. Environ. Manag.267 (2020), 110627, https: //doi. org/10.1016/j. jenvman.2020.110627.

[20] S. Dires, T. Birhanu, A. Ambelu, Use of broken brick to enhance the removal of nutrients in subsurface flow constructed wetlands receiving hospital wastewater, Water Sci. Technol.79 (2019) 156–164, https: //doi. org/10.2166/WST.2019.037.

[21] R. R. Shrestha, R. Haberl, J. Laber, Constructed Wetland technology transfer to Nepal, in: Water Science and Technology, IWA Publishing, 2001, pp.345–350, https: //doi. org/10.2166/wst.2001.0701.

[22] Sani A. R., Dareini F., Treatment of hospital wastewater by vativer and typical reed plants at wetland method, Indian Journal of Fundamental and Applied Life Sciences, 2014 Vol.4 (S3), pp.890 - 897

[23] White J. R., Belmont M. A., Metcalfe C. D., Pharmaceutical Compounds in Wastewater: Wetland Treatment as a Potential Solution. TheScientificWorldJOURNAL (2006) 6, 1731–1736

[24] Kumari A., Mourya N. S., Tiwari B., Hospital wastewater treatment scenario around the globe. Current Developments in Biotechnology and Bioengineering. DOI: https: //doi. org/10.1016/B978 - 0 - 12 - 819722 - 6.00015 - 8

[25] Kumar Swarnakar, A., Bajpai, S., & Ahmad, I. (2023). Performance Evaluation of Different Soil Media by Batch - Operated Pilot - Scale Horizontal Subsurface Flow Constructed Wetlands for Wastewater Treatment. Pollution, 9 (4), 1567 - 1578. https: //doi. org/10.22059/POLL.2023.357480.1855

[26] Swarnakar AK, Bajpai S. (2021). Role of soil organic matter in plant growth forhorizontal flow subsurface constructed wetlandsfor waste water treatment. Poll control, 40 (2): 559 - 561

[27] Swarnakar AK, Bajpai S, Ahmad I. Evaluation of the performance of different soil - base horizontal subsurface flow constructed wetlands for wastewater treatment. European Chemical Bulletin, 12 (7), 2023, 1842 - 1851. https: //doi. org/10.48047/ecb/2023.12.7.1412023.14/06/2023

[28] Swarnakar, A. K., Bajpai, S., & Ahmad, I. (2022, June). Various Types of Constructed Wetland for

Wastewater Treatment - A Review. In IOP Conference Series: Earth and Environmental Science (Vol.1032, No.1, p.012026). IOP Publishing. https: //doi. org/10.1088/1755 - 1315/1032/1/012026

[29] Swarnakar, A. K., & Choubey, S. (2016). Testing and analysis of pond water in Raipur City, Chhattisgarh, India. International Journal of Science and Research, 5 (4), 1962 - 1965.

[30] Kumar Swarnakar, A., Bajpai, S., & Ahmad, I. (2023). COMPARATIVE STUDY OF PILOT - SCALE SOIL BASE HORIZONTAL SUBSURFACE FLOW CONSTRUCTED WETLAND UNDER DIFFERENT OPERATIONAL CONDITIONS FOR WASTEWATER TREATMENT. *Larhyss Journal*, (56).