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Removal Persistent Organic Pollutant in the Leachate by Subsurface Horizontal Flow Construction Wetland in Lab Scale CWs

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Abstract. Hard organic compounds such as humic, fulvic in leachate which require treatment to make it dischargeable into the water stream. CWs is designed in the dimension of DxRxH = 2.5x0.8x0.5m. The filter materials used are small pebbles, crushed stone, and large pebbles. In this work, the effectiveness of removing colour and COD from leachate with *Canna Lily* CWs with activated sludge. Removal of COD and colour by CWs were 75.2% and 80.0% after 5 days, COD removal and colour increase were 9.7%, 5.6%, when adding 200mg of activated sludge to CWs. The quality of leachate is up to standard with HTR of 6 days with COD and 7 days with colour. The treatment time for leachate meets QCVN 40:2011/BTNMT standards is 7 days.

1. Introduction

Landfilling is a predominant method for solid waste disposal in Viet Nam, because of its several advantages such as its simple disposal procedure and low cost. Leachate has a complex composition that can leave a long-term environmental impact if not treated. Leachate has a complex compositions that can bring a long-term environmental impacts when left untreated. Landfill leachate that leached as a result of natural decomposition of organic material, waste component and chemicals dumped in a landfill may post a risk of groundwater contamination if not properly managed. The dark colour of leachate caused by organic dye or biological compounds is a serious problem in many countries. Therefore, the removal of colour is important in environmental remediation. Colour usually becomes the first pollutant to be discriminated by the community and therefore the appearance of dark brownish colour from landfill leachate may cause uneasiness and concern to them. Untreated coloured leachate being discharged to receiving waters imparts colour and thus hinders the growth of aquatic life by decreasing the penetration of sunlight, consequently disturbing photosynthetic activity. The aerobic and anoxic biological treatment methods reduce pollutants but do not thoroughly treat pollutants such as COD, colour and TN. These components are the most significant long-term contaminants in landfills, which tend to accumulate in leachate due to anaerobic metabolism [1].

Many studies have been performed to address these problems with some proposing the removal of nitrogen by applying biological methods in two stages namely, the aerobic nitrification of ammonia to nitrate and the anaerobic/anoxic denitrification of nitrate to nitrogen gas. However, these methods are not effective because of high investment cost and low efficiency. Refractory compounds in the leachate formed by high concentrations of organic matter which includes humic acids, fulvic acids and the hydrophilic fraction contribute a strong yellowy-brown or dark colour to the leachate [2].

Choosing the appropriate leachate treatment process is reliant on pollutants that need to be removed from the leachates. Methods which have been used for colour removal from landfill leachate include, ion exchange [3], coagulation-flocculation [4], electrocoagulation [5], advanced oxidation process [6]. These methods have high treatment costs and cause secondary pollution.

Waste water treatment by Contruction wetlands(CWs) have low treatment cost, high treatment efficiency. Treatment Wetlands, have been used internationally for over two decades in a variety. CWs provide facilities for physical, biological treatment of pollutants in wastewater. The plan in CWs grows and the roots grow in the water column help to reduce the velocity of the flow and to deposit suspended solids. Roots grow to create a medium and promote the biological uptake of nutrients by the plants [7]. Artificial CWs are supported by a constructed materials as the plant roots grow through the materials and into the water, they provide an extensive surface area for microbial biofilm to grow on the roots. These biofilms provide a suitable environment for microorganisms to convert nutrients into a form that can be directly taken up by the plants [8]. CWs commonly use rooted, emergent macrophytes including various species to remove pollutants from water bodies.

2. Materials and methods

2.1. Lab scale CWs

Lab scale CWs with *Canna Lily* were set up in a greenhouse in Thai Nguyen University of Technology. CW is designed in the dimension of DxRxH = 2.5x0.8x0.5m and made of tempered glass which includies 02 compartments: 01 distribution compartment with DxRxH =0.2x0.8x0.5m, 01 compartment containing filter material with the size of 2.3x0.8x0.55m. Filter materials are distributed in 3 layers from the bottom and shown in Table 1 below:

Table 1. Filter materials used in plant filtration tanks

Filter materials	Material height (mm)	Material diameter (mm)	Material porosity (%)	material density (kg/m3)
Small pebbles	50	3-5	50.5 ± 7	1260 ± 35
Crushed stone	200	15-20	52 ± 3	1080 ± 30
Large pebbles	300	30-40	46 ± 3	1450 ± 27

2.2. Leachate sampling and characterisation

The sample leachate was obtained from Da Mai Thai Nguyen City. Sine provides its services for more than 10 years, the produced leachate can be classified as mature or stabilised leachate. The characteristics of leachate are as shown in Table 2. Plants grown in tanks using filtered. *Canna Lily* is selected to be planted in filter tank. *Canna Lily* is a cluster root plant (consisting of many small root strands). Growing roots form the substrate for the microflora then. The filter tank is activate. *Canna Lily* has is the age of 2 cotyledons and is planted in 20cm^2/a plant. Leachate is introduced to activate the filtration tank with the characteristic in Table 2. Activation time is 40 days, Figure 1 (a, b, c).

Table 2. Leachate characteristics in activation CWs

Parameter	Influent	Outfluent	Effective %
pH	6.7-7.1	6.8-7.3	40-80
BOD_5	140-160	32-56	40-80
COD	340-380	224-272	20-41
TN	23. -27.7	6.9-12.9	45-75
TP	3.3- 5.6	0.55-1.9	30-66

(a)

(b)

(c)

Figure 1. Lab-scale CWs (a); Lab-scale CWs one day activation (b); Lab-scale CWs after 40 days of activating (c)

3. Results and discussion

3.1. Effects of COD influent

Leachate study has COD influent from 300-500mg/L, BOD/COD ratio is described 3.2-3.9. The hydraulic retention time of water is 120 hours (HRT = 5 days). The research results are shown in Table 3.

Table 3. Effects of COD influent in CWs

Prameter	Unit	COD = 300 (mg/L)		COD=400 (mg/L)		COD=300(mg/L)	
		Outfluent	Efficiency (%)	Outfluent	Efficiency (%)	Outfluent	Efficiency (%)
pH	-	7.0	-	6.8		6.8	
COD	mg/L	134.6	74.2	104.0	74.7	82.0	74.7
BOD_5	mg/L	44.5	73.5	37.9	72.0	33.0	73.9
TN	mg/L	17.7	77.9	14.5	79.2	10.5	83.4
NH_4^+	mg/L	4.1	90.2	2.9	90.3	2.5	90.7
TP	mg/L	2.5	81.6	2.0	82.7	1.5	84.9
PO_4^{3-}	mg/L	1.1	79.2	1.2	78.3	1.5	78.8
TSS	mg/L	12.4	78.0	13.0	79.9	18.0	77.1
Colour	Pt.Co	215	81.0	208	80.2	185.0	80.3
BOD_5/COD	-	0.32		0.33		0.39	

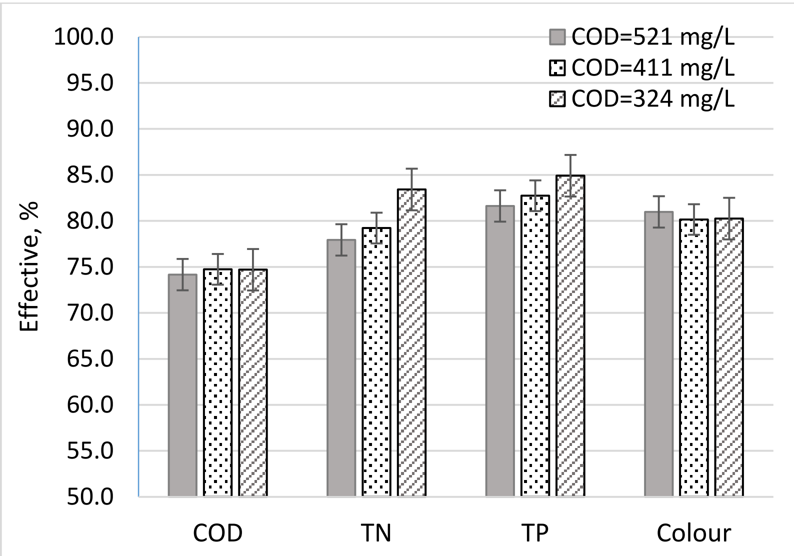

Figure 2. Remove pollutants CWs when changing COD influent

The research results showed that COD treatment efficiency and colour did not increase when changing COD concentration in the inflow as shown Figure 2. After 5 days of processing, the effect of colour treatment reached 80.1-81.0%; COD removal efficiency reached 74.1-75.0%. The pollutants in leachate at this stage are difficult to decompose including linnin, perfluoroalkyl and polyfluoroalkyl substances… Constructed wetlands (CWs) are copyrighted to be cost-effective for removal of many emerging organic contaminants including pesticides Song et al CWs encompass simultaneously biodegradation (aerobic, anoxic, anaerobic) [9], phytoremediation (plant uptake, biodegradation enhancement) and sorption (adsorption, absorption) [10].

However, the removal efficiency of TN and TP increased with increasing inflow load (Figure 2) after 5 days of treatment with Constructed wetlands. The treatment efficiency of TN was 77.9-83.4%, TP was 81.6 to 84.9% (Table 3), especially NH_4^+ is 90.1-90.7%. The metabolism of pollutants is carried out by the respiration of plants and the anaerobic, anoxic and aerobic metabolism of the microorganisms around the root zone [11]. The results of COD treatment in the filtration yard are consistent with the research of M Scholz [12]. Research results of Reza Bakhshoodeh [13] for CW ventiver effectively remove COD 53%, BOD 75% but the BOD5/COD ratio is 0.75.

3.2. Remove pollutants in CWs and CWs and activated sludge

If adding 200mg/L of activated sludge to CWs the results showed that the treatment efficiency of filtration yards increased significantly. COD removal efficiency increased by 9.7%, TN 7.1% (Figure 3). The colour level increased by 5.6%. TP removal efficiency increased insignificantly by 2.2%. In activated sludge there are aerobic and anaerobic microorganisms *Pseudomonas, Alcaligennes, Pseudomonas stuzeri, Aerobacter aerogennes, Bacillus subtilis, Nitrosomonas, Alcaligennes, Flavobacterium.* They support the treatment of CWs.

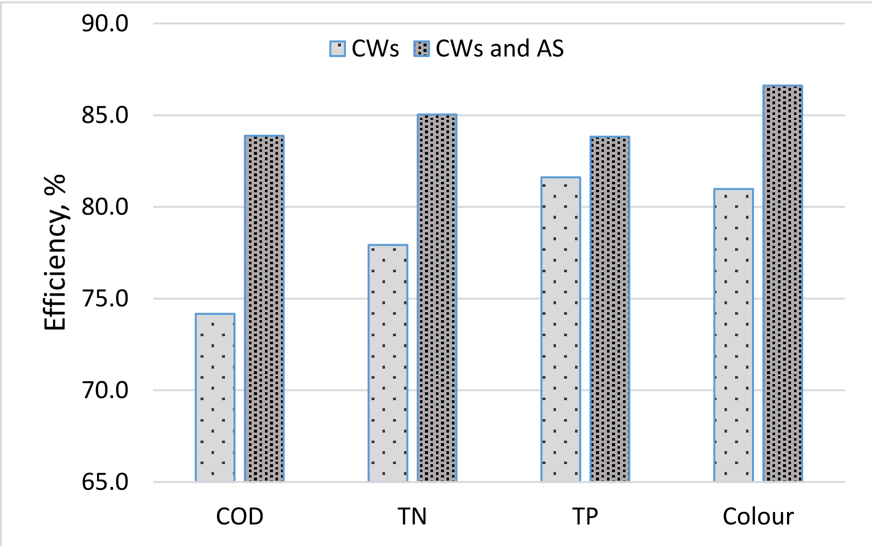

Figure 3. Compare removal of CWs and CWs and activated sludge

3.3. The effect of time on removal of pollutants in CWs

The study was conducted with COD 411 mg /l, Colour 847 Pt.Co. Hydraulic Retention Time from 0 to 192 hours. 200mg/L activated sludge is added. The result shows the ability to remove COD and increase colour as time increases. However the removal process is not significant. COD removal is 13.5%. Colour level of 16.6% after 2.5 hours. CWs pollutant removal efficiency increased rapidly after 3 to 5 hours. The highest TN removal was 77.9%, while COD and colour were 74.2; 73.0%, respectively. This shows that the ability to treat COD and colour of CWs is slower than that of TN. SS removal has not changed significantly over time as depicted Figure 4.

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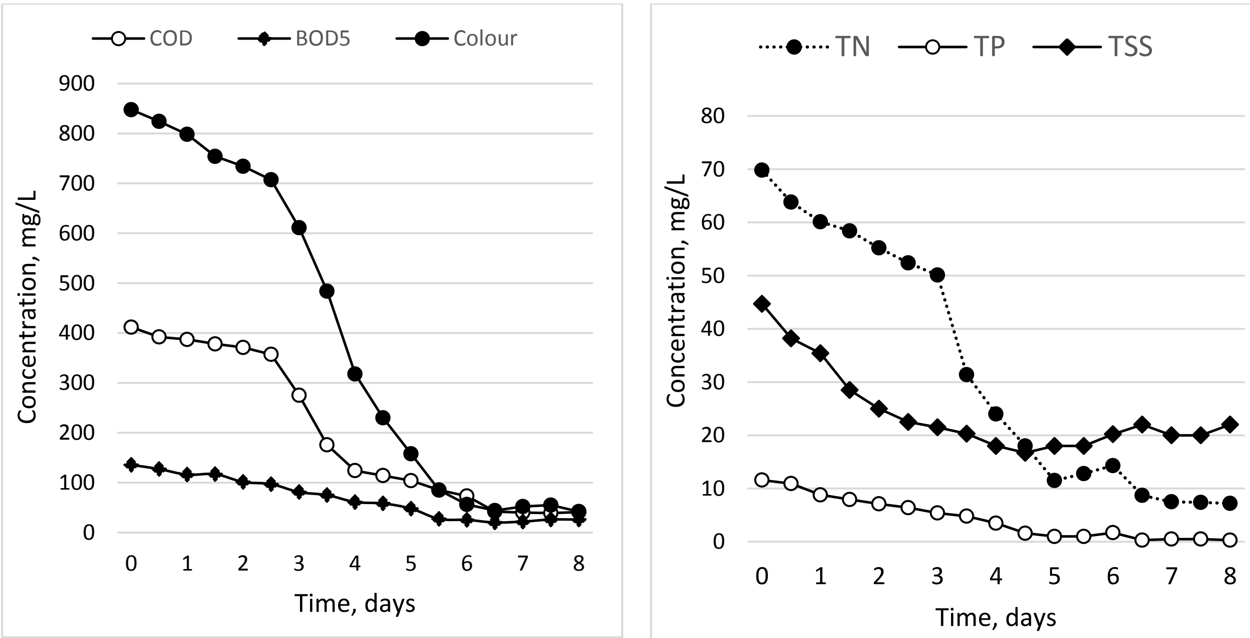
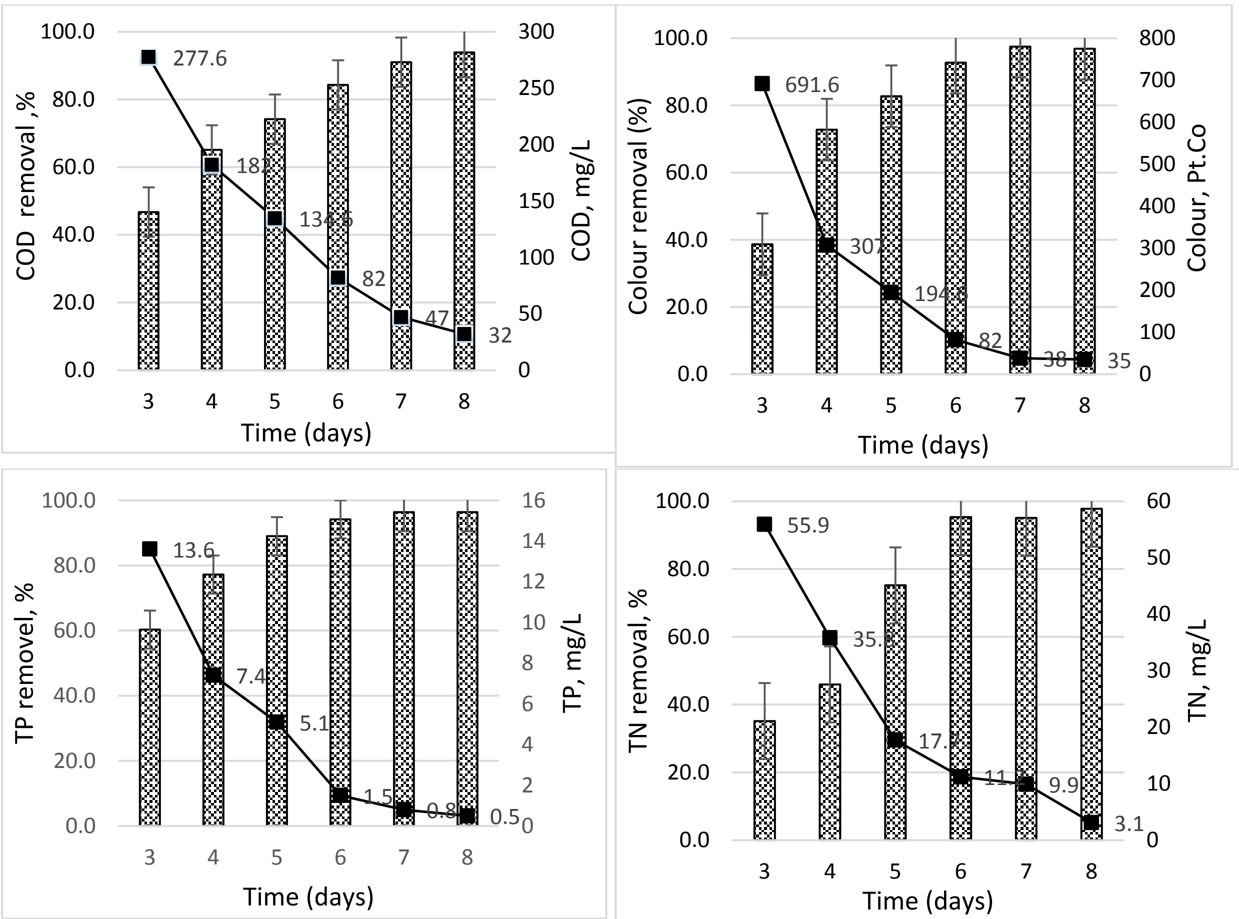


(a)



(b)

Figure 4. The effect of time on the processing efficiency of CWs (a); The effect of time on the processing efficiency of CWs (b)

Table 4. Effect of retention time in CWs

Parameter	Unit	Hydraulic Retention Time (HRT, days)							
		Infuent	3	4	5	6	7	8	Standard[1]
pH	-	6.8	6.8	7.2	6.9	7	7.2	6.8	5.5-9.0
COD	mg/L	521	277.6	182	134.6	82	47	32	75
BOD_5	mg/L	168	135.6	92.7	44.5	23.3	21.3	15	50
TN	mg/L	80.2	55.9	35.8	17.7	11.2	14.9	3.1	20
NH_4^+	mg/L	40.7	26.4	22	10.1	1.9	2	0.9	5
TP	mg/L	13.6	5.4	3.1	1.5	0.8	0.5	0.5	4
PO_4^{3-}	mg/L	5.3	4.2	0.1	0.83	0.63	0.3	0.2	-
TSS	mg/L	56.4	21	18.2	12.4	12.7	20.75	15	50
Colour	Pt.Co	1128	691	307	194.6	82	38	35	50

[1]Standard of the Environmental Quality QCVN 40:2011/BTNMT (National technical regulation on Industrial watewater Regulations 2011)

Results in Table 4 shows, removal of COD, TN, TP, very high colour from time interval of 3-5 hours then slow down. The parameters of TN and TP are standard with HRT of 5 days, only COD and colour after 7 days meet effluent standards of 40: 2011/BTNMT as Table 4. Biodegradability was estimated by the ratio of BOD_5 to COD and was calculated to be approximately 0.75 for the influent leachate. Average COD removal efficiencies are 53.7% in the Vetiver CWs. The average BOD_5 removals of 74.5% [13]. Statistical analysis results show that removal efficiency of organic matter in the Vetiver CW is significantly higher than control CWs which is in agreement with observations reported in the literature [14,15]. Major organic matter removal mechanisms in CWs as discussed in the literature are sedimentation and filtration of suspended solids in the gravel bed, plant uptake and biological decomposition processes by microorganisms under aerobic, facultative and anaerobic conditions [16]. Although no measurement on the organics filtration was performed but total suspended solids removal proved to be 73% and 35% for Vetiver and control CWs.

4. Conclusion

Preliminary research results show the ability of CWs to treat the difficult metabolites of leachate. When changing COD inflow from 300-500 mg/L, the treatment efficiency of filtration yard is not changed. Increasing the effectiveness of removal of pollutants in CWs by adding activated sludge to the filtration yard 200mg/L, COD removal efficiency increased by 9.7%, TN by 7.1%; The colour level increased by 5.6%. The quality of leachate is above discharge standards with HRT 6 days of COD and colour in 7 days. HRT 6 days of COD and colour in 7 days. The treatment time for garbage water meeting QCVN 40:2011/BTNMT standards is 7 days.

5. References

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