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Constructed Wetland Units Filled with Waterworks Sludge for Remediating of Wastewater Contaminated with Congo Red Dye

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Abstract

The disposal of textile effluents to the surface water bodies represents the critical issue especially these effluents can have negative impacts on such bodies due to the presence of dyes in their composition. Biological remediation methods like constructed wetlands are more cost-effective and environmental friendly technique in comparison with traditional methods. The ability of vertical subsurface flow constructed wetlands units for treating of simulated wastewater polluted with Congo red dye has been studied in this work. The units were packed with waterworks sludge bed that either be unplanted or planted with Phragmites australis and Typha domingensis. The efficacy of present units was evaluated by monitoring of DO, Temperature, COD and dye concentration in the effluents under the variation of detention time (1-5 day) and dye concentration (10-40 mg/L). The maximum removal of dye and COD were 98 and 82% respectively for 10 mg/L of Congo red dye after five-day hydraulic retention time (HRT). The results have shown that the removal of COD and dye concentration significantly increased with higher contact time and lower dye concentration. The values of monitored parameters adopted to evaluate the wastewater quality (i.e. DO, COD and Congo red dye) are satisfied the requirements of irrigation water. The dye concentration variation in the effluent with contact time was formulated efficiently by Grau kinetic model. Functional groups (specified by FT-IR analysis) have a remarkable role in the entrapment of dye on the waterworks sludge bed.

Keywords: Constructed wetland, Phragmites australis, Typha domingensis, and Congo red dye.

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1- Introduction

"Water pollution" represents the familiar threat to the global environment in the last decades. It means that there is deterioration in the quality of water resources (like surface water and groundwater) due to development adopted by human to improve all living aspects. For example, the disposal of wastewater resulted from domestic, commercial and industrial uses without applied proper treatment can cause severe pollution for receiving water bodies. The influences of this pollution are fatal for entire ecosystem not only for human life [1–6].

A dye is a colouring substance and it mostly applies as solution in water. Pigments and dyes appear to be coloured due to absorption of specific wavelengths of light more than others especially in the visible spectrum (400–720 nm). Moreover, the structure of dyes contains alternate single and double bonds; so, they show resonance property which considers the stabilization factor for organic compounds. For industrial and domestic requirements, the formation of dye (or colouration) and its favourable compounds in water are not acceptable according to many environmental regulations. Colour can be imparted due to the presence of different dyeing substances such as tanning, dyes, lignin, inorganic pigments.

The industries like pharmacological manufacturing, dye and dye intermediates [7], paper and pulp [8], kraft bleaching [9], tannery [10], fabric [11], cosmetics, paper, and rubber are different sectors that employ the dyes.

Congo red dye is the first synthetic dyestuffs of the direct type which previously utilized to dye cotton but then substituted by dyes more resistant to washing and light. At pH>5, the aqueous phase will have a red colour in the presence of this dye; however, the colour become blue at more acidic conditions. Red dye is classified as an acidic anionic dye with chemical formula of $C_{32}H_{22}N_6Na_2O_6S_2$. The molecular weight of this dye is 696.66 g/mol and the absorbance can be spectro-photometrically monitored at the maximum wavelength (λ_{max}) equal to 497 nm.

Dye treatment is associated with many problems because most dyes are stable and non-biodegradable. Several methods have investigated to treat dye-polluted wastewater, by physical and chemical processes, like flocculation with lime, coagulation, adsorption, ultrafiltration and reverse osmosis. These methods are limited in use due to the low efficiency, high cost and lack of applicability to avoid a variety of dyes in addition to the forming of toxic pollution resulted from excessive use of chemicals.

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The adsorption method is implemented using bark, rice husk, activated carbon, peanut shell, charcoal, cotton waste, clay, banana waste, coconut shell and clay gas residue [12–14]. This technique is not useful because it only depends on transferring the dye from the liquid to solid phase. Therefore, sorbent regeneration and subsequent treatment of solid waste must apply and these processes are costly. Alternatively, biological approach is applied to treat dye wastewater because of its low cost, high efficacy and acceptable environmentally.

Constructed wetlands (CWs) are engineering systems commonly utilized due to their simplicity, appropriateness, low operating cost and low energy requirements. These systems have been implemented to treat the wastewater through benefit from natural processes that cause an evidence reduction in the requirements for mechanical devices and energy. Previous publications revealed the efficiency of CWs in treating different types of wastewater like; urban runoff, animal wastewater and mine disposal [15,16], petroleum wastewater [17,18], textile wastewater [19] and domestic sewage [20,21]. Treatment by CWs mainly depends on the application of different aqueous species such as Phragmites australis, Eichhornia crapssipes, Typhonium flagelliform, Typha, Azolla caroliniana, and lemnaetc for removing of dye and other pollutants from wastewater [22,23].

Survey related with sludge of waterworks signified that the Europe alone can generate several million tons every year of this byproduct and it is expected to increase drastically in the future. This sludge can dispose either to the sanitary landfills or to the river. Accordingly, cheaper options have been proposed by water companies to minimize the problems associated with sludge disposal [24]. In this regard, the usage of this sludge as substrate in CWs is one of these options which investigated in this work. Hence, the main objective is achieved the experimental investigation supported with kinetic model for vertical flow CWs filled with waterworks sludge to treat water polluted with Congo red dye in the presence of Typha domingensis and P. australis compared with units free from plants.

2- Materials and Scheme of Operation

Simulated wastewater was prepared with four different concentrations of Congo red dye in the range from 10 to 40 mg/L. The characteristics of tap water utilized in the preparation of such wastewater were; pH=7.3, DO=7.26 mg/L, Temp.=17 °C, TDS=523 mg/L and EC=1046 dS/cm.

Waterworks sludge Fig. **1** was collected from groundwater reservoir in Al-Amin water supply treatment plant / Baghdad/ Iraq. This plant uses alum salt to purify raw water. The sludge was dried in the air for three days, crushed and grinded to be in size from 63 µm to 1 mm. Coefficient of hydraulic conductivity, bulk density and porosity for this sludge were 2.93×10^{-4} m/s, 1.06 g/cm^3 and 0.42 respectively.

The pilot-scale units of CWs were established during September of 2019 and, then, the planting stage has begun on 1 October 2019; however, the operation and monitoring processes were implemented in 1 December of the same year and extended to 31 March 2020. The operation process consists of two phases:

a) The first phase (or acclimation period): This phase was continued about two months from 1 October to 30 November to enhance the acclimation of the plants (height ≈ 0.5 m). The plants were trimmed to a certain height and the removed parts can be returned to the experimental units.

b) Second phase: This phase requires to operate the CWs units in batch mode for duration from 1 December 2019 until 31 March 2020 for different concentrations of influent Congo red dye as mentioned previously. The batch tests were conducted with detention time equal to 5 days and the parameters like pH, Temp., DO, TDS, EC, Colour, COD, NH_4-N, NO_3-N and dye concentration were chosen to evaluate the performance of treatment process. COD can be determined by “closed reflux 5220 C method” in “Standard Methods for the Examination of Water and Wastewater and Environmental Chemistry”. The water temperature (°C) and DO (mg/L) were measured by “hand-held mi 605 portable Dissolved Oxygen, MARTINI (Italy)”. The removal efficiency (*R*) of any measured parameter was calculated by the following equation:

$$R = \frac{C_e - C_i}{C_i} \times 100 \quad (1)$$

Where: C_e and C_i are the effluent and influent values respectively.

To determine the dye concentration (X) based on the absorbance (Y) of UV-VIS spectrophotometer, the calibration curve was constructed and the following fitted equation can be applied in the determination of concentration:

$$Y = 0.0414X - 0.0017, R^2 = 0.9958 \quad (2)$$

Fig. 1. Waterworks sludge from groundwater reservoir and complexes in Al-Amin/ Baghdad/ Iraq.

3- Description of CWs Units

Four identical plastic containers Fig. **2** were utilized to represent the units of VSSF CWS with dimensions of; total height=60 cm, top diameter= 50 cm and bottom diameter= 40 cm. Each unit was packed with coarse gravel (>10 mm) at the bottom to prevent the outlet clogging and; then, another layer of gravel (<10 mm) must situate on the previous layer. The outlet valve was located at the bottom of each unit somewhere above the base with 5 cm. This valve is utilized for sampling and to empty of treated water. It is connected with PVC pipe (12.5 mm in diameter) to specify the elevation of water in CW unit. Perforated PVC tube (50 mm in diameter, 75 cm in length) was embedded in substrate of each unit to increase the aeration of bed [25].

The main bed is the waterworks sludge (WS) with the depth of 150 mm that packed above the gravel layers. One unit vegetates with Phragmites australis while Typha domingensis was inserted in the other unit. The remaining two units in each group were not vegetated and they can be used as control units. The planted units can be recognized from unplanted by subscript "P" with the first letter of the adopted plant. The first unit will be unplanted and operated with tap water only; so, the subscript "C" can be used to recognize it as a control unit. The water contaminated with soluble dye will be fed to the remaining three units. Table **1** presents the adopted designations for describing the CWs units to facilitate the discussion of obtained measured results.

Fig. 2. Unplanted and planted units of CW installed in this work

Table 1. Designations and details of CWs units implemented in this work

Unit designation	Plant type	Influent
CWWSC	------	Tap water
CWWS	------	Congo red-water
CWWSPP	P. australis	Congo red-water
CWWSPT	Typha domingensis	Congo red-water

4- Operation of the System

The polluted water was injected to the CW unit from top side and remained within this unit for 5 days which represents the "contact time". This means that the wastewater poured for the first day of the operation cycle with closing the outlet valve and keeping the water for 5 days. The sample must be taken 30 mL of treated water after the end of each day by opening the "outlet valve" mentioned previously. Between two successive tests, the unit must be free from the wastewater and this duration (= 2 weeks) named the "resting time" which required to obtain partially saturated conditions. After finishing the operation cycle, the outlet valve was opened and treated water can leave the CW along the day. As bed drains, the air is drawn into the bed and re-aerating the microbial. For the unplanted vertical subsurface flow CW units, the same previous working plan was achieved.

5- Kinetic Modeling

The biological and transport processes occurred within the CW unit can describe by the kinetic model [26]. The constants of such model are identified as the growth or bio-kinetic coefficients. Several kinetic models are available in the previous studies to formulate the mentioned processes like "first-order model" and "Grau second-order model" [27–29]. Second-order model of Grau (Eq. 3) was applied in the current investigation for simulating the dye removal in terms of its concentrations with different values of HRT [30,31]:

$$S_e = S_i\left(1 - \frac{1}{b + \frac{a}{HRT}}\right) \qquad (3)$$

Where: S_i is the inlet concentration (mg/L), S_e is solute concentration in effluent (mg/L). Kinetic constants (a and b) have calculated through fitting Eq. 3 with measured data by "Solver" option in Excel 2016.

6- Results and Discussion

6.1. Experimental Measurements

The density and height of plant increased dramatically with the age from 5 and 0.15 to be 41 plants/unit and 1.70 m respectively after 136 days for P. australis; however, these indicators were 32 plants/unit and 1.15 m beyond same duration for Typha. The pH, temperature, DO, TDS, EC, COD, and red dye concentration monitored.

Regardless the HRT and dye concentration, the pH of treated water resulted from CWWS, CWWSPP, and CWWSPT units lie in between 6.5 and 8.5 which represent WHO limits [32]. Although the values of TDS were increased beyond the treatment process; however, the measured maximum value of is equal to 748 mg/L which satisfies the prescribed value by WHO (2004) < 1000 mg/L.

In addition, the concentration of nitrates in simulated wastewater prior to the treatment by VSSH CW packed with waterworks sludge was varied from 4.3 to 12.8 mg/L as dye concentration changed from 10 to 40 mg/L. However, these values of nitrates are satisfied the acceptable limit specified by WHO (< 50 mg/L) but unfortunately, they exceeded the prescribed standard of EPA (< 0.05). Results revealed that the removals of nitrate are improved with increase of HRT and decrease of influent concentration especially with presence of plant. For HRT of 5 days, when the influent concentration of nitrate equal to 4.3 mg/L the removal efficiencies have values of 61, 66 and 68% for treated water resulted from CWWS, CWWSPP and CWWSPT units respectively. These removals will be equal to 53, 61 and 63% for same units and HRT when influent concentration of nitrate increased to become 12.8 mg/L; however, the decrease of HRT to be 1-day can reduce the removal percentages to become 45, 50 and 52% respectively.

Table **2** lists the inlet and outlet concentrations of DO versus the detention time for adopted units of CW versus different dye concentrations. Measurements certified that the influent concentrations of DO in simulated wastewater are ranged from 7.45 to 7.9 mg/L and they decrease with increase of HRT because of consumption the oxygen in the degradation of organic contaminants which measured by COD and dye concentration. It is obvious that the minimum value for effluent concentrations of DO reached to 3.98 mg/L which approximately consistent with EPA standards (4-5 mg/L) as cited in USEPA (2006) to ensure aerobic oxidation.

Table **3** and Table **4** are signified that there is evident reduction in the concentrations of dye and COD; however, this reduction can be justified by reduction in DO values. It seems that the presence of plant with increase of HRT can cause significant reduction in the organic contaminants for treated wastewater.

Table 2. Concentrations of DO versus contact time in the planted and unplanted units of CW filled with waterworks sludge as function of dye concentrations

DO (mg/L)	HRT (day)	CWWS				CWWSPP				CWWSPT			
		10	20	30	40	10	20	30	40	10	20	30	40
Influent	0	7.45	7.7	7.85	7.9	7.45	7.7	7.85	7.9	7.45	7.7	7.85	7.9
	1	6.71	7.02	7.14	7.22	5.82	5.9	6.06	6.13	5.98	6.1	6.29	6.35
	2	6.31	6.61	6.83	6.89	5.37	5.55	5.74	5.82	5.67	5.73	5.91	5.99
Effluent	3	6.00	6.2	6.38	6.44	4.80	5.1	5.27	5.37	5.26	5.35	5.51	5.6
	4	5.54	5.91	6.08	6.15	4.29	4.68	4.86	4.93	4.83	5.04	5.34	5.44
	5	4.9	5.6	5.81	5.89	3.98	4.23	4.38	4.47	4.40	4.68	4.75	4.83

Table 3. Concentrations of COD versus contact time in the planted and unplanted units of CW filled with waterworks sludge as function of dye concentrations

COD (mg/L)	HRT (day)	CWWS				CWWSPP				CWWSPT			
		10	20	30	40	10	20	30	40	10	20	30	40
Influent	0	30.51	70.34	102.33	126.2	30.51	70.34	102.33	126.2	30.51	70.34	102.33	126.2
	1	16.59	39.98	62	78.5	9.44	22.4	35.5	47.32	9.31	20.9	35.3	46.43
	2	16.02	38.54	59.65	76.22	8.11	19	33.25	43.16	7.86	18.66	32.33	41.89
Effluent	3	14.7	36.02	57.07	72.69	6.88	18.14	30.9	41.26	6.37	17.86	29.78	39.75
	4	14.15	35.45	53.51	69.25	6.53	16.74	26.81	37.97	6.05	15.96	25.78	35.91
	5	13.78	34.22	51.57	65.35	6.21	15.34	24.96	33.81	5.5	13.71	24.04	32.35
Min. Removal (%)		46	43	39	38	69	68	65	63	69	70	66	63
Max. Removal (%)		55	51	50	48	80	78	76	73	82	80	77	74

Table 4. Concentrations with removal efficiencies of red dye versus the contact time in the planted and unplanted units of CW filled with waterworks sludge

Conc. of dye (mg/L)	HRT (day)	CWWS				CWWSPP				CWWSPT			
Influent	0	10	20	30	40	10	20	30	40	10	20	30	40
Effluent	1	0.717	1.836	3.06	4.88	0.596	1.594	2.982	4.32	0.572	1.546	2.913	4.28
	2	0.62	1.442	2.76	4.484	0.5	1.4	2.7	4	0.5	1.4	2.7	3.99
	3	0.476	1.352	2.631	4.296	0.451	1.302	2.547	4.16	0.403	1.208	2.409	4
	4	0.403	1.008	2.121	3.616	0.282	0.702	1.767	3.16	0.258	0.718	1.707	3.16
	5	0.379	0.96	2.046	3.44	0.282	0.766	1.767	2.88	0.234	0.67	1.635	2.832
Min. Removal (%)		93	90	90	88	94	92	90	89	94	92	90	89
Max. Removal (%)		96	95	93	91	97	96	94	93	98	97	95	93

Additional unplanted CW unit filled with waterworks sludge (designated as CWWSC) was irrigated with tap water to be a “control” unit to evaluate performance of previous units. This unit can be specified the influence of dye presence on the tap water characteristics. Measurements proved that the pH of tap water was 7.3 which reduced with elapsed time until reached to 7 beyond five days due to the CO_2 dissolution.

The pH values were increased after one-day detention time and then began to decrease for units fed with contaminated water. This difference in behavior of pH between units fed with tap water only and that irrigated with contaminated water may be resulted from interaction between substrate and biofilm which caused initial increase in the pH for unit contained wastewater.

Other observations certified that the influent values of TDS, EC, NH_4-N and NO_3-N for tap water are equal to 523 mg/L, 1046 μS/cm, 0.33 mg/L, and 8.1 mg/L; however, these values are slightly different from that of wastewater entering to the CWWS, CWWSPP and CWWSPT units. This difference may be related to the quality of water especially the tests on the control unit are conducted in the middle of March while on the units fed with wastewater in the January and February.

This means that the addition of Congo red dye will not have significant effects on the values of TDS, EC, NH_4-N and NO_3-N. Results revealed that the TDS and EC values were increased in the effluent from control units with percentage reached to 10% and also the values of NH_4-N and NO_3-N have been decreased with maximum percentage of 40%. This behavior may be resulted from the activity of biomass due to the availability of COD (i.e. dye organic compound) and, in addition, the role of used vegetation.

The monitoring process elucidates that the quantity of dissolved oxygen in the influent tap water for CWWSC unit conducted in March is 7.26 mg/L which slightly different from dye-water. This difference can be resulted from the change in the quality of tap water during testing months (i.e. January, February and March). High difference in the COD of influent according to dye concentration can be recognized; it has values of 30.51, 70.34, 102.33 and 126.2 mg/L for 10, 20, 30 and 40 mg/L dye concentrations respectively. The COD is equal to 7.21 mg/L for control unit.

The big difference in the values of COD between simulated wastewater and tap water can be resulted from the presence of red dye. Measurements for treated wastewater certified that the dissolved oxygen was reduced with detention time due to the consumption of DO in the dye oxidation.

The DO and COD in the effluents for this unit at 5 days were 5.82 and 3.05 mg/L respectively. Finally, the temperatures of influent and effluent for control unit were identical to values of other units irrigated with wastewater.

6.2. Grau Second-Order Kinetic Model

Dye concentrations in effluent treated by planted and unplanted units (CWS, CWSPP, CWSPT) are formulated by 2nd kinetic model of Grau using “solver” in Excel 2016. The constants of this model (a and b) plus determination coefficient (R^2) and sum of squared error (SSE) are major outcomes of fitting process.

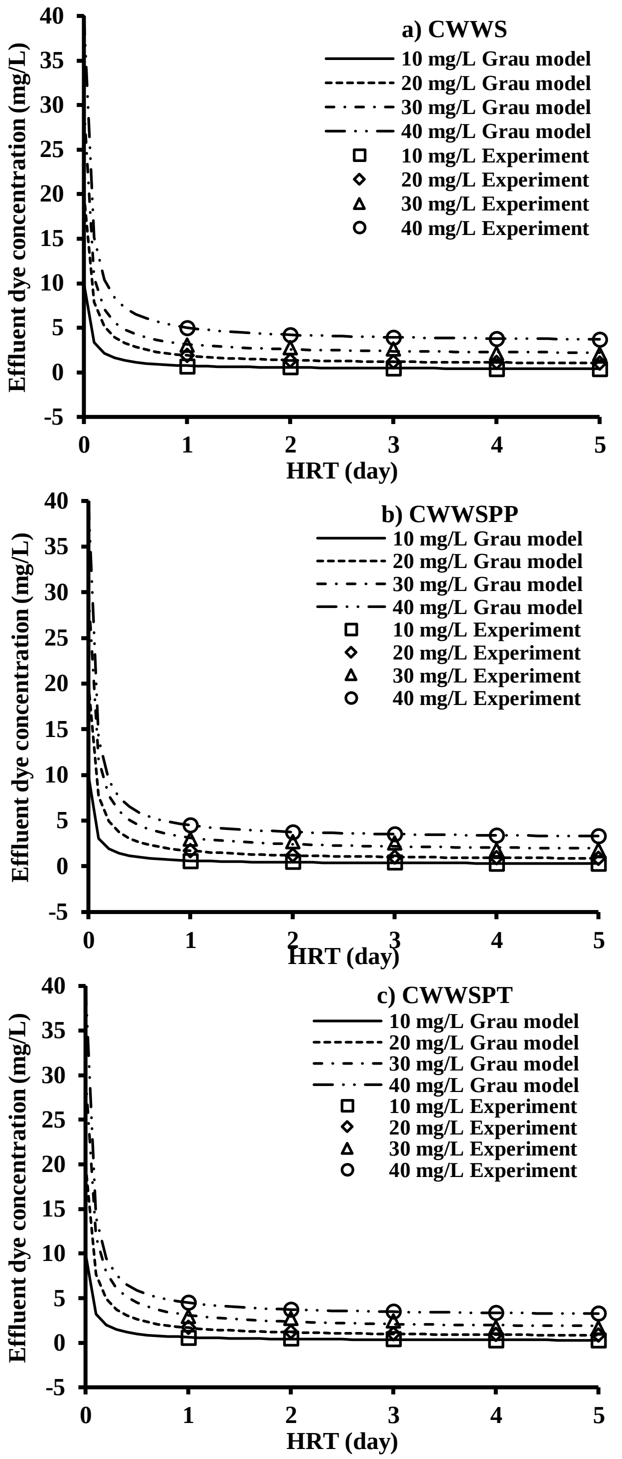

Fig. 3. Measurements with Grau predictions for effluent dye concentrations versus detention time in the planted and unplanted units filled with waterworks sludge

The SSE and R^2 are suitable statistical indictors to find the concurrence between the predicted and measured concentrations. Fig. **3** plotted the Grau relationship between effluent dye concentrations versus HRT for adopted influent dye concentration in the CW units packed with waterworks sludge; however, constants resulted from fitting with R^2 and SSE have been inserted in Table **5**. Fig. **3** with this table revealed that the model describes the experimental outcomes in acceptable manner.

Table 5. Parameters of Grau model for effluent dye concentrations versus time in the present units

Influent dye conc. (mg/L)	CWWS				CWWSPP				CWWSPT			
	a	*b*	R^2	SSE	*a*	*b*	R^2	SSE	*a*	*b*	R^2	SSE
10	0.0478	1.0331	0.8899	0.0093	0.0420	1.0250	0.7937	0.0158	0.0446	1.0208	0.7891	0.0184
20	0.0612	1.0430	0.9028	0.0495	0.0585	1.0347	0.6866	0.1977	0.0592	1.0319	0.7096	0.1833
30	0.0477	1.0702	0.7847	0.1605	0.0579	1.0588	0.7076	0.3627	0.0602	1.0547	0.7144	0.3822
40	0.0519	1.0921	0.7746	0.3280	0.04545	1.0814	0.5510	0.7408	0.0461	1.0796	0.6077	0.6058

6.3. Overall Performance of CW Units

Results signified that the planted and unplanted CWs packed with waterworks sludge have a satisfactory ability in the reclamation of red dye-wastewater.

Several parameters influenced on the performance of adopted units and, consequently, on the quality of treated wastewater such as influent concentration, HRT, and type of plant (Phragmites australis and Typha domingensis) under natural environmental conditions. In spite of these units operated under influent concentrations ≤ 40 mg/L, two additional tests with concentrations of 250 and 1000 mg/L are conducted for monitoring their ability in reduction of dye concentration.

Table **6** proves that the removal efficiencies of dye with influent concentration of 250 mg/L lie within the range (86.3-88.4%) for all units under consideration after retention time equal to 5 days; however, the increase of influent concentration to be 1000 mg/L will cause a decrease in these efficiencies to be ranged from 81.6 to 83.6%.

The results proved that the plants have positive effect on the treatment process; however, P. australis and Typha domingensis have approximately the same effect on the treated wastewater. Ultimately, the treated effluents consider acceptable for irrigation according to standards of WHO (2004) and USEPA (2006).

Another indicator that can be used to evaluate the current treatment feasibility is the difference in the degree of colour between effluent and influent.

Fig. **4** lists a set of photos for appearance of effluent and influent after detention time of 5 days for 40 mg/L influent dye concentration. It seems that the colour of the wastewater entering to all units is red which can remove with various percentages depended on the kind of CWs units.

Table 6. Overall performance of CW units at HRT 5 days for different influent dye concentrations

	Conc. (mg/L)	Removal efficiency (%)		
		CWWS	CWWSPP	CWWSPT
Red dye	10	96.2	97.2	97.7
	20	95.2	96.2	96.7
	30	93.2	94.1	94.6
	40	91.4	92.8	92.9
	250	86.3	87.6	88.4
	1000	81.6	83.2	83.6
COD	30.51	54.8	79.6	82.0
	70.34	51.4	78.2	80.5
	102.33	49.6	75.6	76.5
	126.20	48.2	73.2	74.4
	582	37.9	65.3	65.9
	1422	37.9	65.3	65.9

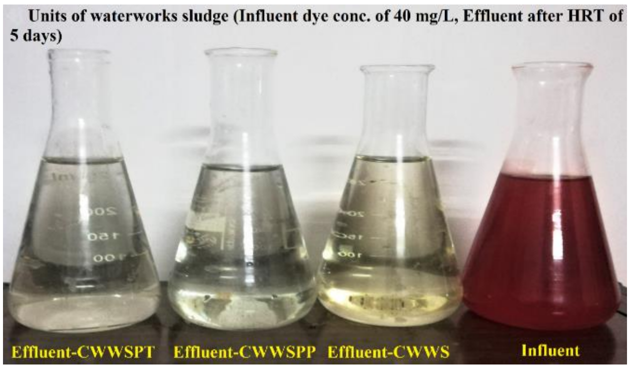

Fig. 4. Appearance of wastewater after 5 days for dye concentration in influent of 40 mg/L

7- Functional groups

For virgin waterworks sludge, the spectrum of IR Fig. **5** elucidates that the existence of O-H peak intensity in the broader range from 3400 to 3700 cm^{-1}. This indicates the presence of hydrated aluminum silicates or an amorphous silicate material. The bending mode of H_2O molecules can result from the band at 1626 cm^{-1}. Also, asymmetric stretching vibrations of silica (Si–O–Si) is recognized due to band at 1000–1085 cm^{-1}. However, silica and quartz can be identified in the range of bands 460–500 and 770–796 cm^{-1} respectively [33].

On the other hand, the change in the intensity of waterworks sludge may be due to the interaction with the functional group of organic matter (residual of the root in sample) such as NH, C=C and C-C. While the test of FT-IR after and before dye sorption signifies the existence of peaks at 1431.2 and 2873.9 cm^{-1} (i.e. C=C in the dye aromatic ring). Also, shifts in other peaks reveal the sorption of dye on the silanol group.

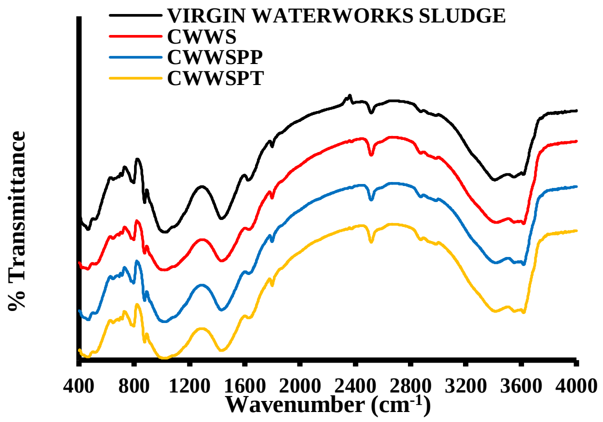

Fig. 5. Spectrums of FT-IR outputs for waterworks sludge of planted and unplanted beds before and after dye removal

8- Conclusions

The outputs of this work demonstrated the ability of cultivated and uncultivated wetland unit with a vertical subsurface flow in the treatment of textile wastewater in terms of Congo red dye concentration, dissolved oxygen, COD. Concentrations of red dye have been selected with range from 10 to 40 mg/L with removal efficiency exceeded 88% for 1-day detention period, and this value increased with increasing detention time and decreasing dye concentration.

Observations showed that the Phragmites australis and Typha domingensis used in the experimental units had roughly the same effect on the monitoring parameters adopted to assess the quality of the treated wastewater. Also, there is a slight difference in the performance of the cultivated and non-cultivated units on the effluent quality of CW. An apparent decrease in COD values (at least 38%) was identified for the current units at a dye concentration of 10 mg/L for the lowest value of contact time; however, this decrease is associated with a depletion in the dissolved oxygen values that are consumed in the decomposition process.

According to several agency guidelines, effluents based on pH, COD, and dye concentration values are suitable for irrigation purposes. Grau second-order kinetic model was well described the variation of effluent dye concentration with HRT for present units. FT-IR analysis demonstrated that several functional groups enhanced dye uptake specifically identical to SiO_2.

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وحدات الأراضي الرطبة المعبأة بخبث محطات معالجة المياه لمعالجة مياه الصرف الملوثة بصبغة الكونغو الحمراء

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الخلاصة

يمثل التخلص من النفايات السائلة النسيجية في الاجسام المائية السطحية قضية حرجة لأن لها تأثيرات سلبية على تلك الاجسام لاحتواء تلك النفايات على الاصباغ. تعتبر طرق المعالجة البيولوجية مثل الأراضي الرطبة المشيدة أكثر فعالية من حيث التكلفة وصديقة للبيئة مقارنة بالطرق التقليدية. تمت دراسة قدرة وحدات الأراضي الرطبة المُنشأة ذات التدفق تحت السطحي العمودي على معالجة المياه العادمة المحاكاة الملوثة بصبغة الكونغو الحمراء. كانت الوحدات معبأة بمخلفات أحواض مياه الصرف الصحي التي إما أن تكون غير مزروعة أو مزروعة مع Phragmites australis وTypha domingensis والتي تعتبر مألوفة في بيئة العراق. تم تقييم فعالية هذه الوحدات من خلال مراقبة تركيز الأكسجين المذاب ودرجة الحرارة والمادة العضوية والصبغة في النفايات السائلة في ظل اختلاف وقت الاحتجاز (1–5 أيام) وتركيز الصبغة (10–40 مجم / لتر). كان الحد الأقصى للتخفيضات في الصبغة والمادة العضوية 98 و82٪ على التوالي لـ 10 ملجم / لتر من صبغة الكونغو الحمراء بعد خمسة أيام وقت التلامس هيدروليكي. أظهرت النتائج أن إزالة COD وتركيز الصبغة زاد بشكل ملحوظ مع ارتفاع وقت التلامس وانخفاض تركيز الصبغة. تلبي قيم المعلمات المراقبة المعتمدة لتقييم جودة مياه الصرف الصحي (أي DO، COD وصبغة الكونغو الحمراء) متطلبات مياه الري. تمت صياغة اختلاف تركيز الصبغة في التدفق مع وقت التلامس للوحدات الحالية بكفاءة بواسطة نموذج Grau الحركي. المجموعات الوظيفية المحددة بواسطة اختبار FT-IR لها دور ملحوظ في احتجاز الصبغة على طبقة الحمأة الخاصة بالمحطات المائية.

الكلمات الدالة: الأراضي الرطبة، القصب، البردي، صبغة الكونغو الحمراء.