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Effectiveness of Phytoremediation Treatment of Pre-Treated Domestic Wastewater

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ABSTRACT

Wastewater contamination which causes health, environmental and economic impacts is one of the most common environmental issues. Several methods have been used for the upgrade of the existing wastewater treatment facilities, nevertheless, the application of phytoremediation treatment is a promising and environmentally friendly method to avoid the secondary contaminations posed by the treatment dosage in other advanced treatment methods. The current work aimed to assess the phytoremediation treatment of the pre-treated domestic wastewater using the *Salvinia molesta* and water hyacinth plants. The water quality tests were performed in the current research to evaluate the effects of the phytoremediation treatment using the *Salvinia molesta* and water hyacinth plants on the responses of the water quality parameters. The study focused on varying two main parameters, namely the pH and the hydraulic retention time (HRT), while the removal rate was determined based on the reduction in the chemical oxygen demand (COD), total dissolved solids (TDS), total nitrogen (TN) and turbidity. The optimal removal of COD, TDS, TN and turbidity in the current study was 56.47, 83.00, 52.12, and 79.98% for *Salvinia molesta* as well as 48.81, 24.00, 13.56 and 19.89% for water hyacinth.

Keywords: phytoremediation, wastewater, salvinia molesta, water hyacinth

INTRODUCTION

Domestic wastewater generation is strongly associated with the development and population growth, where the growing production and industries contribute to increased generation (Hülsen *et al.*, 2016). The generated domestic wastewater is one of the most troubling issues around the world, as many counties have restored to various methods of treatment, including the chemical, physical and biological methods to dispose of this type of waste safely to the environment (Corbella & Puigagut, 2018). Wastewater could be classified into three types, including domestic, industrial and stormwater wastewater. Many countries intensify their efforts to monitor industrial wastewater due to the seriousness of its contents, which may lead to an environmental and health disaster if it is discharged into the environment without treatment (Fahad *et al.*, 2019), while they tolerate other sources of wastewater, which are usually disposed of to the natural sources directly or after pre-treatment (Powley *et al.*, 2016). All types of wastewater are characterized by their physicochemical diversity in terms of the high contents of chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS), turbidity, total phosphorus and other characteristics (Choi *et al.*, 2017).

The domestic wastewater contains a high ratio of organic and nutrient matters where pre-treatment processing is not enough to remove it (Choi *et al.*, 2017). The pre-treatment process usually involves the technologies of the bar screen, grit chamber, and sedimentation tank, in which the characteristics of wastewater are optimized before the disposal stage (Moharram *et al.*, 2016). Moreover, some large domestic facilities use advanced technologies such as activated sludge processes in treating these types of wastewater (Varjani *et al.*, 2020). However, all these technologies, including the chemical dosage treatment, are expensive and require regular maintenance (Hülsen *et al.*, 2016).

In the last decades, the biological treatment methods of wastewater have attracted the researchers' attention, due to their simplicity, low contamination and cost, and high function in wastewater treatment (Goswami *et al.*, 2018). The biological treatment methods are considered the alternative techniques of the physical and chemical methods which suffered from several disadvantages (Carboneras *et al.*, 2018). Various biological methods have shown high performance in treating domestic wastewater, including the employment of polymer materials (polyaluminium chloride (PAC)), utilization of the microorganisms (bacteria, fungi, and algae), and the purification methods by the plant roots (wetland plants) (Sandoval *et al.*, 2019). Among all these, the plant root was one of the most promising methods due to its sustainability and efficiency in removing nutrients from the domestic wastewater (Wu *et al.*, 2019).

Salvinia molesta plant is a perennial plant that floats on the surface of the water without soil attachment. The *Salvinia molesta* plant is characterized by its rapid spread and its ability to absorb nutrients, which made it a promising plant in wastewater treatment (Ng & Chan, 2017). *Salvinia molesta* plant prefers to grow in the slow-moving water (lakes, pounds) that contains high nutrients (phosphorus, nitrogen), making it a strong candidate for wastewater treatment (Al-Baldawi *et al.*, 2020). Many studies have been performed in wastewater treatment and heavy metals removal using the *Salvinia molesta*, which showed a high performance of COD, TDS, BOD_5, and TP removal estimated at 76, 97, 82, and 80% respectively (Chandanshive *et al.*, 2016; Munfarida *et al.*, 2020; Kumar & Deswal, 2020).

Water hyacinth which is also known as *Eichhornia crassipes*, has similar characteristics to *Salvinia molesta* in terms of the growing environment, nutrients absorption and the high performance in wastewater treatment. However, water hyacinth is distinguished from *Salvinia molesta* by the rapid growth more than (Kumar & Deswal, 2020). Many studies have proven the removal performance of the wastewater contamination of the water hyacinth which was estimated at 94, 72.54, 83.78 and 53.44% for COD, TDS, BOD_5, and TP respectively (Varanasi *et al.*, 2018; Kumar *et al.*, 2018; Kumar *et al.*, 2019; Qin *et al.*, 2016). Both *Salvinia molesta* and water hyacinth are adapted to the same environmental conditions which are suitable at pH 7.5 and temperature between 25 and 36°C (Kumar & Deswal, 2020).

Although many studies reported the treatment performance of aquatic plants, further studies are required to prove the workability of these promising techniques under various conditions. Therefore, the current study has been performed to investigate the phytoremediation technique using *Salvinia molesta* and water hyacinth for treating the pre-treated domestic wastewater collected from the wastewater treatment plant.

Many treatment plants subject their wastewater to pre-treatment to ensure the wastewater quality before the disposal stage. These facilities are usually focusing on the main characteristics of the water quality, including TSS, TDS, COD, BOD and ammoniacal nitrogen (AN) while they neglect the contents of nutrients such as TN and TP which are the reason the growth and spread of the harmful algae bloom in water bodies (Ding *et al.*, 2018). The chemical and physical treatment technologies are commonly used in these facilities including the aeration, sedimentation, aerobic and anaerobic, and chemical dosage technologies which suffer from the high run and maintenance cost and the lack of nutrients removal (Dvořák *et al.*, 2016).

Due to the presence of several pollutants in domestic wastewater, high dosage of chemicals are required in the chemical treatment methods, which could cause secondary pollution (Al-sahari *et al.*, 2020). Furthermore, the usage of the soil and sludge in the physical methods could increase the water turbidity which required an advance technology as the reverse osmosis (RO) purification (Parlar *et al.*, 2019). Furthermore, many studies have shown high optimization of the wastewater characteristics by employing bacteria and fungi in the biological treatment methods as the utilization of activated sludge; however, these types of technologies are only applied in advanced treatment plants to avoid the bacterial and fungal infections. This study aimed to assess the phytoremediation treatment of the pre-treated domestic wastewater using the *Salvinia molesta* and water hyacinth plants.

Domestic wastewater characteristics

Domestic wastewater is one of the most generated among all wastewater types which is associated with the increase of population and development. This type of wastewater poses a significant risk for the environment if it does not subject to the proper treatments methods before the disposal phase (Mara, 2013). The domestic wastewater contains highly polluting and heavy compounds generated by human products such as the *xenobiotics* (from shampoo and soap products), the organic compound (from food products), nutrients (from urine and human excrement), and many other compounds (Choi *et al.*, 2017).

On the other hand, the pre-treatment technologies used in many facilities to optimize the wastewater characteristics are not sufficient for the safe disposal phase and require further treatment. The coagulation and flocculation processes are the most common methods employed in many facilities to mitigate the pollution in the generated wastewater before the disposal stage; however, many studies have proven that these methods could be insufficient to remove the organic and nutrients matter. A study performed by Al-Hamadani *et al.* (2011), showed that the usage of PACI coagulant in the coagulation process has recorded a medium removal for the COD estimated by 55%, besides, the performance of FAC coagulant in terms of COD removal was close to PACI, where according to Mishra & Mohapatra, (2012) only 42.5% of COD was removed during the treatment processes. Many other studies achieved a high removal of organic and nutrients by using various coagulants; however, the extensive dosage of the coagulants could lead to secondary pollution (Al-Sahari et al, 2020)

Microbial technology as the microbial fuel cell (MFC) captured the researchers' attention in the last decade due to its easy usage, low-cost compared to some technologies, and the ability to convert the waste to energy. However, this technology has several disadvantages such as the low ability to remove nutrients (Mateo-Ramírez *et al.*, 2017).

Domestic wastewater treatment technologies

Various technologies are used conventionally to treat domestic wastewater before the disposal stage. The conventional technologies used are not sufficient to make the wastewater match with the disposal standards, as they suffer from several limitations. Some of the conventional treatment technologies such as chemical precipitation (CP) and biological activated sludge (BAS) are inefficient in removing organic and nutrient compounds even though they are widely used in the industrial and domestic facilities (Crini & Lichtfouse, 2019). According to Quan *et al.*, (2010), the CP treatment method has removed 15–16.1% of AN and 62.5–64.3% of the total COD, while the remaining concentration of AN and COD was to be disposed of by natural processes. The continuous disposal of the organic and nutrients into the environment destroys the ecosystem and natural water sources (Warner *et al.*, 2013). Organic and nutrient substrates are considered the main supplying sources of harmful algae growth which are considered extremely dangerous to the aquatic and human life (Chislock *et al.*, 2014). The other treatment methods including coagulation/flocculation (C/F), and advanced oxidation processes (AOP), showed a high and acceptable performance; however, these technologies suffer from several issues such as the difficulty of applying them on a pilot scale, the high cost and the requirement of monitoring (Crini & Lichtfouse, 2019).

The collected studies explain the needs for further treatment units after the conventional units and before the disposal stage; the study performed by Schröder *et al.*, (2007) indicated the need of using phytoremediation treatment methods after the conventional treatment. Many biological treatment methods have been used in the literature as additional purification methods, such as microbial fuel cell (MFC), soil filtration and phytoremediation methods. All these methods were dependent on employing the organisms in the natural for optimizing the wastewater characteristics (Rahimnejad *et al.*, 2015).

Domestic wastewater treatment using the phytoremediation methods

The phytoremediation technologies are usually employed to purify the polluted soil, air and polluted wastewater (Reichenauer & Germida, 2008). These technologies involve the utilization of the plants and their associated microorganisms to remove the pollutants from the contaminated sources (Das *et al.*, 2018). These technologies are attractive due to their low costs; however, it is insufficient in treating the high contamination wastewater before it is subjected to a primary treatment. The organic and nutrient compounds are the main target for the phytoremediation, where this method is ineffective for heavy metals removal. However, many studies have been performed to assess the ability of phytoremediation treatment methods all around the world, where much progress has been shown in using this method in the USA, China, India, and European countries (Rai, 2012; Ansari *et al.*, 2014; Guittonny-Philippe *et al.*, 2014; Krayem *et al.*,2016; Vymazal *et al.*, 2016; Wang *et al.*, 2018), besides, several countries have conducted the phytoremediation methods for treating the heavy metals in the polluted lakes and streams (Maisa'a *et al.*, 2015; Ruiz-García *et al.*, 2016; Al-Khafaji *et al.*, 2018).

Table 1 displays the performance of various plants in the phytoremediation treatment methods of wastewater. The phytoremediation method has achieved high removal efficiency from 5 to 18 days. The literature has shown that the efficiency of phytoremediation treatment is strongly associated with the type of plant used in the process. The phytoremediation method usually takes from 5 to 10 days to achieve high removal of the organic and nutrient substrates.

Phytoremediation mechanism

The phytoremediation technique involves employing natural phenomena of the plants in degradation of the organic and inorganic pollutants through their microbial rhizosphere flora and roots. The phytoremediation method is classified into six processes including phytoextraction, phytodegradation, phytostimulation, rhizofiltration, phytodesalination, and phytovolatilization (Ifon *et al.*, 2019). In the phytoextraction process, the plants employ their absorption characteristic to remove the pollutants from the water (Ali *et al.*, 2013). Moreover, in the hyperaccumulators process, the microorganisms in the plant roots absorb a high amount of the contaminants. The high concentration of metals can sometimes harm and kill the plants (Singh *et al.*, 2013). In the phytodegradation process, the organic contaminants are degraded by plant that employ the root microorganisms and the enzymes secreted by their roots to degrade the organic compounds, which are subsequently absorbed by the plant and released through transpiration (Al-Baldawi *et al.*, 2015). The phytostimulation process is close to the phytodegradation process, wherein the plant enhances the microbial activities of the soil by the microorganisms stuck on the roots to degrade the organic contaminants on soil (Wang *et al.*, 2013). The phytostimulation process occurs in the rhizosphere where the plant roots are surrounded with soil (Kvesitadze *et al.*, 2006). This process depends strongly on the carbohydrates and acids released by plants where they enhance the activities of the microorganisms to degrade the organic contaminants (Dzantor, 2007). The enhanced microorganisms, in turn, work on digest and breakdown the toxin and organic substrates into a harmless form (Hossain *et al.*, 2017). The rhizofiltration process is usually employed to purify the groundwater from the excess nutrients and substances through the root absorption characteristic (Lee & Yang, 2010). The phytodesalination process is the method to remove the salinity from the soil to improve its fertility; however, this process occurs only with the plants that can adapt with saline soil (Ali *et al.*, 2013). In the phytovolatilization process, the substrates are absorbed from the soil through the transpiration and plant to evaporate into the atmosphere (Limmer & Burken, 2016).

Table 1. Removal of organic and nutrient using various plants

Plant Type	Duration (day)	COD (%)	TDS (%)	TN (%)	Turbidity (%)	References
Hydrophytes	5	58.65	NR	63.80	NR	Zhang *et al.*, (2007)
Lemna sp.	10	54.01	27.37	NR	50.42	Dipu *et al.*, (2011)
Eichhornia sp	10	61.20	52	NR	42.78	Dipu *et al.*, (2011)
Typha sp.	0.71	78	21	NR	NR	Valipour *et al.*, (2014)
Water Hyacinth	14	79	73.02 (TSS)	76.61	NR	Valipour *et al.*, (2015)
Salvinia molesta	8	69	77	NR	34	Chandanshive *et al.*, (2016)
Spirodela polyrhiza	12	68	86 (TSS)	NR	96	Ng *et al.*, (2017)

NR – not recorded.

METHODOLOGY

In the first phase of this study, a sample of the pre-treated wastewater was taken to the laboratory to be assessed. In the second phase, the phytoremediation system was installed at the effluent point of the pre-treated domestic wastewater of a local wastewater treatment plant. In the third phase of the study, the plants were used to treat the wastewater for 5 days and the wastewater quality was monitored every day.

The tests were performed after the collection phase immediately to avoid changes in quality.

This study was focused on the further treating the pretreated wastewater by using phytoremediation method. Table 2 shows the parameters, method and instrument or equipment that was used in this study.

Tow rectangular tanks were built in the current study one of them filled by *Salvinia molesta* plant and the other one by the water hyacinth plant. Each tank was designed to accommodate 21 L with a dimension L×W×H of 0.70×0.40×0.30 m, while the effective depth was 0.25 m. The plants were placed in the surface of each tank with submerging their roots inside the tanks. The plants were arranged parallel to the direction of flow of wastewater to facilitate the effluent flow of wastewater.

The *Salvinia molesta* and the water hyacinth plants were brought from a pond and washed by clean water to remove the adhering dirt. Both tanks were filled by the pre-treated wastewater and each plant was planted in a different tank. The treatment operation was started after the planting stage and the removal of the parameters was assessed every 24 hrs for 5 days. The pre-treated wastewater was subjected to the water quality tests, namely pH, COD, TDS, TN and turbidity before and after the phytoremediation.

The experimental runs were designed according to two independent factors, namely the hydraulic retention time (HRT) and pH, and four dependent variables responses, namely COD, TDS, TN and turbidity.

RESULTS AND DISCUSSION

All the obtained results and data of experimental runs were analyzed in this study to support and clarify the objectives of the research. The analysis results of treated wastewater quality tests were included in this section to display the effects of the phytoremediation process with using *Salvinia molesta* and water hyacinth plants on improving the wastewater quality.

The results of the performed tests as in Table 3, where the COD and TN (as NO_3^-) values were complying to the Environmental quality (sewage) regulations (EQA) standard for Malaysia by 49 and 15.96 vs. 120 and 20 mg L^{-1} in the standard. However, the TDS value was very high compared to the Malaysian standard for wastewater disposal. Bhatti *et al.*, (2014) has mentioned a high removal of all parameters during the conducted study except the removal of TDS which recorded very low removal during the treatment of UASB and H_2O_2 which might explain the high TDS in this study.

Table 2. List of parameters, instrument, and test methods of the water quality

Parameter	Method/ Standard	Equipment
pH	Standard method APHA 4500-HB	pH HI 8424
Total Dissolved Solids (TDS)	2540 D	Shel Lab Oven/Sensor
Chemical Oxygen Demand (COD)	Standard method APHA 5220-D (direct reading)	DR 6000
Total Nitrogen (TN)	APHA standard method 10072	DR6000
Turbidity	NTU standard (direct reading)	Turbidity Meter TB400

DR6000; HACH UV VIS Spectrophotometer.

Table 3. Wastewater quality before the phytoremediation process

Parameter	Unit	Value	
		Reads	Average
pH	-	6.29-7.10	6.70
COD	mg L^{-1}	45-53	49
TDS	mg L^{-1}	750-1050	900
TN	mg L^{-1}	10.73-10.19	10.46
Turbidity	NTU	14.90-20.50	17.70

In the current study, two experimental conditions of the wastewater treatment using the *S. molesta* and water hyacinth plants were conducted for 5 days per each condition. The pH level in the first experimental condition was adjusted to 5, while the second condition it was adjusted to 7 by using 1N NaOH or H_2SO_4.

COD removal efficiency using *Salvinia molesta*

Total of ten runs were made during this study using *Salvinia molesta* and the results are as shown in Table 4. The removal of COD was increased along with HRT. In the first day of treatment, *Salvinia molesta* was removed 9.14% of the COD from the collected sample. The removal increased gradually until it reached 54.84% in the fifth day under the first condition (pH=5).

Under the second experimental condition (pH=7), *Salvinia molesta* was removed 8.01% of the COD concentration on the first day while the final removal efficiency of the COD after day 5 was estimated by 56.47% which is better than the first condition results. Chandanshive *et al.*, (2016) has recorded 69% removal efficiency of COD in 8 days which consider a matching value with the obtained values in the current study.

TDS removal efficiency using *Salvinia molesta*

The removal of TDS in the phytoremediation treatment using *Salvinia molesta* plant was high from the first time where it recorded 11% of removal efficiency in the first day. The removal efficiency was high compared to the COD removal, where it reached up to 70% in the samples under both (pH=5 and 7) in 5 days (Table 4). This study achieved high performance of TDS removal compared to Chandanshive *et al.*, (2016) study, which stated that the removal efficiency of TDS reached 77% in the 8th day which is closed to the obtained value in this study. However, the reason for this difference could result from the contamination concentration of the wastewater, whereas pre-treated wastewater was used in the current work. The result indicates that the HRT was strongly effected on the TDS removal while there was a slight effect of the pH value on the removal efficiency of TDS.

TN removal efficiency using *Salvinia molesta*

Most of the plants use the nitrogen as a source of nutrients to grow, especially the aquatic plants and algae. The concentration of the TN in the collected pre-treated wastewater was not high where it estimated by 10.46 mg L^{-1}. The phytoremediation treatment using the *Salvinia molesta* plant was effective in removing the TN from the wastewater, wherein the removal was increased gradually from the first day until the fifth day under both experimental conditions until reached 51.84% under pH value of 5 and 52.12% under pH value of 7 (Table 4).

The result shows the HRT and pH effects on the removal performance of TN during the phytoremediation process in the current project where it shows high effect of the pH and the slight effect of HRT.

Turbidity removal efficiency using *Salvinia molesta*

The turbidity concentration on the collected wastewater was recorded by 17.70 mg L^{-1}. The removal performance of the turbidity through

Table 4. Removal efficiency using phytoremediation treatment of *Salvinia molesta*

pH	HRT	COD	TDS	TN	Turbidity
5	1	9.14	11.00	10.91	21.14
5	2	19.84	29.00	12.51	33.12
5	3	36.04	46.00	29.10	39.15
5	4	46.21	66.00	40.01	53.15
5	5	54.84	79.00	51.84	77.91
7	1	8.01	18.00	9.84	29.15
7	2	20.13	43.00	21.45	34.12
7	3	35.43	59.00	30.15	50.51
7	4	47.08	73.00	45.41	69.05
7	5	56.47	83.00	52.12	79.98

the phytoremediation treatment of *Salvinia molesta* reached 77.91% after 5 days from the starting time of the experimental under pH level of 5 (Table 4). The removal of turbidity was increased slightly at pH 7, where the maximum removal of the turbidity under pH value of 7 was estimated by 79.98%

By comparing with the obtained results of turbidity removal using the *Salvinia molesta* plant mentioned by Ng & Chan, (2017), the turbidity achieved very high removal estimated by approximately 87.57% in only 2 days; however, this can be referred to the low turbidity concentration which recorded by 7.56 Vs 17.70 mg L^{-1} in the current study.

The result indicated the effects of both factors on the turbidity removal where when the pH and HRT gradually increase the removal of turbidity.

COD removal efficiency using water hyacinth

Table 5 shows the removal efficiency of the COD using the water hyacinth plant. As well as any phytoremediation plants, the COD removal was increased gradually by the time where it increased from 12.42% to 48.81 from the first day to the fifth day gradually under pH level of 5. The removal of COD was recorded lower percentage under the second condition (pH=7) estimated by 44.87% in the fifth day. The results show the effects of HRT factor on the COD removal. In the comparison with the previous studies, Valipour *et al.*, (2015), has recorded a removal percentage of COD estimated by 79% in 14 days which is considered a proportion identical to the obtained results in the current study if the concentration of the contamination and HRT between studies are taken in the consideration.

TDS removal efficiency using *Water hyacinth*

In the current work, water hyacinth had very low removal of TDS under both conditions, where the removal reached 24.00% in the fifth day in the first condition (pH=5) and 20.00% under the second condition (pH=7). TDS removal in both conditions was gradually increased until the day three, then in the fourth and fifth days it decreased (Table 5). According to Munavalli & Saler, 2009, they mentioned that the performance of water hyacinth was very high in COD removal while there were no effects on the TDS removal.

TN removal efficiency using water hyacinth

As well as the TDS removal, TN concentration was recorded a slight drop during the phytoremediation treatment of water hyacinth under both conditions, where the TN concentration in 5 days dropped from 10.46 to 9.04 mg L^{-1} and decreased from 10.46 to 9.63 mg L^{-1} in the first and second conditions experimental respectively (Table 5). Fang *et al.*, (2007) study indicated that the water hyacinth plant requires a long HRT to efficiently remove the TN estimated between 14 to 44 days which could support the low removal performance in the current study.

Turbidity removal efficiency using water hyacinth

The turbidity removal performance of the phytoremediation treatment of water hyacinth was not stable under both conditions. The instability of the turbidity concentration in the wastewater could be referred to the high numbers of the water hyacinth roots which are very sensitive to any vibration. Many studies reported low

Table 5. Removal efficiency using phytoremediation treatment of water hyacinth

pH	HRT	COD	TDS	TN	Turbidity
5	1	12.42	8.00	3.10	1.09
5	2	17.03	16.00	2.60	5.66
5	3	29.34	28.00	8.94	17.45
5	4	35.66	25.00	12.21	20.66
5	5	48.81	24.00	13.56	19.89
7	1	10.37	10.00	0.51	1.58
7	2	14.98	14.00	1.91	1.28
7	3	30.06	28.00	4.25	5.51
7	4	33.11	22.00	8.03	4.33
7	5	44.87	20.00	7.92	5.29

Figure 1. *Salvinia molesta* and water hyacinth roots after 5 days of phytoremediation

removal of turbidity by using the water hyacinth in the phytoremediation process. Among these studies, Alade & Ojoawo, (2009) reported a turbidity removal efficiency of water hyacinth for 28 days only at 25.98%.

Removal mechanisms

The mechanism of plants to remove the contaminants from the water lies on the absorption of plants roots (Ifon *et al.*, 2019). The phytoremediation technique involves employing natural phenomena of the plants in degrade the organic and inorganic pollutants through their microbial rhizosphere flora and roots (Figure 1). Figure 1A shows *Salvinia molesta* with the high contamination suspended on its roots after 5 days of phytoremediation, while Figure 1B shows the water hyacinth roots with the stacked substrates after 5 days of processing

CONCLUSION

The current study was done to evaluate the phytoremediation treatment of the pre-treated domestic wastewater using the *Salvinia molesta* and water hyacinth plants, which was achieved through the implementation of four phases started with the sample collection and assessment and ended with the identification of the phytoremediation performance. In the current study, the experimental runs were designed with main factors (pH level and HRT). Four responses were assessed in the current study including COD, TDS, TN and turbidity. The phytoremediation treatment performance showed promising results with the utilization of the *Salvinia molesta* plant, where the optimal removal efficiency of COD, TDS, TN and turbidity reached 56.47, 83.00, 52.12, and 79.98% respectively. The phytoremediation treatment performance of the water hyacinth plant was low comparing to the *Salvinia molesta* plant where the optimal removal efficiency of COD, TDS, TN and turbidity were estimated by 48.81, 24.00, 13.56 and 19.89%. In conclusion, the presented phytoremediation study showed a clear comparison between *Salvinia molesta* and water hyacinth plants in the treatment of the pre-treated domestic wastewater.

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