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USING AQUATIC PLANTS FOR DEGRADATION OF TSS, BOD AND COD IN DOMESTIC WASTEWATER *Actinoscirpusgrossus* IN FLOATING TREATMENT WETLAND SYSTEMS (FTWs)

Syafrizal[1*], Suhendrayatna[2], Muhammad Zaki[2], M. Nasir[1]
[1]Center For Environmental Studies, University of Islamic State Ar-Raniry, Banda Aceh, Indonesia
[2]Department of Chemical Engineering, Faculty of Engineering, University of Syiah Kuala, Banda Aceh, Indonesia

**Email Correspondence: syafrizal.tl@ar-raniry.ac.id*

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ABSTRACT

Wetlands, as part of ecological technology commonly applied in wastewater treatment, are an innovative solution in environmental protection and restoration. Floating Treatment Wetland Systems (FTWs) are a new concept in wastewater treatment using macrophytes rooted in aquatic plants modified as floating systems. Use of a local aquatic plant that is often found and thrives as a weed in rice fields throughout Aceh, namely *Actinoscirpusgrossus*. Variables varied according to plant height, pond I 90 cm – 150 cm, pond II 50 cm – 90 cm and pond III control without plants, influent and effluent were analyzed every two weeks for 18 weeks with 9 analytical sampling times. The results of the domestic wastewater experimental parameter test showed that the average Degradation Efficiency (% DE) was pH 6.92, Total Suspended Solid (TSS): 98.28%, Biological Oxygen Demand (BOD): 97.77% and Chemical Oxygen Demand (COD): 98.30%, very significant results. The management process of regularly cutting plants is an important part for the *Actinoscirpusgrossus* aquatic plant to achieve optimum results in processing wastewater, namely for 112 days with a maximum plant growth height of 165 cm and 173 cm for the two variations of the experimental ponds.

Keywords : Domestic Wastewater, Floating Wetland System, *Actinoscirpusgrossus.*

ABSTRAK

Lahan basah, sebagai bagian dari teknologi ekologi yang biasa diterapkan dalam pengolahan air limbah, merupakan solusi inovatif dalam perlindungan dan restorasi lingkungan. Floating Treatment Wetland Systems (FTWs) *adalah konsep baru dalam pengolahan air limbah menggunakan makrofita yang berakar pada tanaman air dimodifikasi menjadi sistem terapung. Pemanfaatan tumbuhan air lokal yang banyak ditemukan dan tumbuh subur sebagai gulma di persawahan seluruh Aceh, yaitu Actinoscirpusgrossus. Variabel bervariasi menurut tinggi tanaman, kolam I 90 cm – 150 cm, kolam II 50 cm – 90 cm, dan kolam III sebagai kontrol tanpa tanaman, influen dan efluen dianalisis setiap dua minggu sekali dalam durasi 18 minggu dengan 9 kali pengambilan sampel analitik. Pengujian parameter dengan percobaan pada air limbah domestik menunjukkan hasil yang signifikan dengan efisiensi degradasi rata-rata (% DE) dengan hasil pH 6.92, Total Suspended Solid (TSS): 98.28%, Biological Oxygen Demand (BOD): 97.77% dan Chemical Oxygen Demand (COD): 98.30%. Proses pengelolaan pemotongan tanaman secara berkala merupakan bagian penting bagi tanaman akuatik Actinoscirpusgrossus guna mencapai hasil yang optimal dalam pengolahan air limbah, yaitu dalam durasi waktu 112 hari*

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dengan tinggi pertumbuhan tanaman maksimal 165 cm dan 173 cm untuk dua variasi kolam percobaan.

Kata kunci : *Air Limbah Domestik, Sistem Lahan Basah Terapung, Actinoscirpusgrossus.*

Introduction

The most dominant pollutant in water bodies comes from domestic wastewater whose presentation can reach 60-70% (Filliazati et al., 2011). Wastewater treatment technology with energy and centralized costs has proven to be ineffective in resolving complex wastewater, related problems resulting from rapid urbanization (Liu et al., 2014a), especially in the city of Banda Aceh.

The idea of Constructed Wetlands (CWs) has emerged and is becoming a viable option for wastewater treatment today and was recognized as an attractive alternative to conventional wastewater treatment methods. This system offers all the requirements for low and sustainable operational costs (Kivaisi, 2001); (Haberl, 1999). Different types of CWs include: (i) Surface Free Water flow (FWS); (ii) Subsurface Flow (SSF); (iii) combined (hybrid) system; and, (iv) Floating Treatment Wetlands (FTWs). The selection of all types of artificial wetland construction above is very dependent on target needs, especially regarding the maintenance system, geographical location, cost, available area, and processing objectives (Horner et al., 2012).

The current rapid development in processing domestic wastewater, one of which is the bioremediation system (Vijayaraghavan & Balasubramanian, 2015) uses phytoremediation techniques (phyto which means plant and remedial which means clean) by directly utilizing local natural green plants to absorb/remove pollutants through the roots and translocate them throughout plant parts, various plant species are used (Sharma et al., 2014). As indicated by (Valipour & Ahn, 2016), the plant species used for phytoremediation must be native to the local area and have a fast growth rate, a large root system, a high biomass yield, be able to adapt to various habitats, have a high tolerance and the ability to accumulate pollutants. on the top of the ground. Several environmental factors such as temperature, pH, solar radiation and water salinity can influence plant growth and their performance in phytoremediation.

From several studies that have been carried out by researchers (Liu et al., 2014b), (Tanaka et al., 2006) and (Kantawanichkul et al., 2003) previously, the aquatic plant *Actinoscirpusgrossus* is a plant that is very suitable for the phytoremediation system. This plant is superior to several other similar plants, both in reducing levels of BOD, COD, NH_4+-N, NO_3-N, TP, fecal coliform, Ammonium, besides being resistant to seasons, weather, local plants and being considered a weed, has a root system, which is abundant and strong, and has a large biomass yield and is very suitable in tropical areas (Jinadasa et al., 2006).

Therefore, the author wants to conduct research on processing domestic wastewater by the aquatic plant *Actinoscirpusgrossus* using the Floating Treatment Wetland System (FTWs). Research with this system has never been carried out using the aquatic plant *Actinoscirpusgrossus* so the author hopes to get test values from design and operational parameters that are more economical and feasible to be

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implemented as a wastewater processing system in the city of Banda Aceh in the future.

Methods

The phytoremediation container used was modified from wood and vinyl materials available on the market with dimensions L x W x H, namely 5.0 m x 0.6 m x 0.4 m. To support the plants so that they do not fall and spread inside the CWs, stereoforms and wooden latches are used which are placed between the plants. The influent was collected in a holding tank equipped with a water discharge controller before being distributed to the research ponds (3 ponds) which are pumped from the drainage using an electric pump. The effluent was collected in a mineral water bottle container prepared from used 600 mL mineral water bottles. *Actinoscirpusgrossus* plants were taken from rice fields in Gampong Ilie Ulee Kareng Banda Aceh using manual procedures. Plant size was grouped into two groups according to the research variables, the first group had an average height of 50-90 cm while the second group had a height of 100-150 cm (Syafrizal et al., 2020). The view of the Floating Treatment Wetland System (FTWs), in detail as shown in Figure 1.

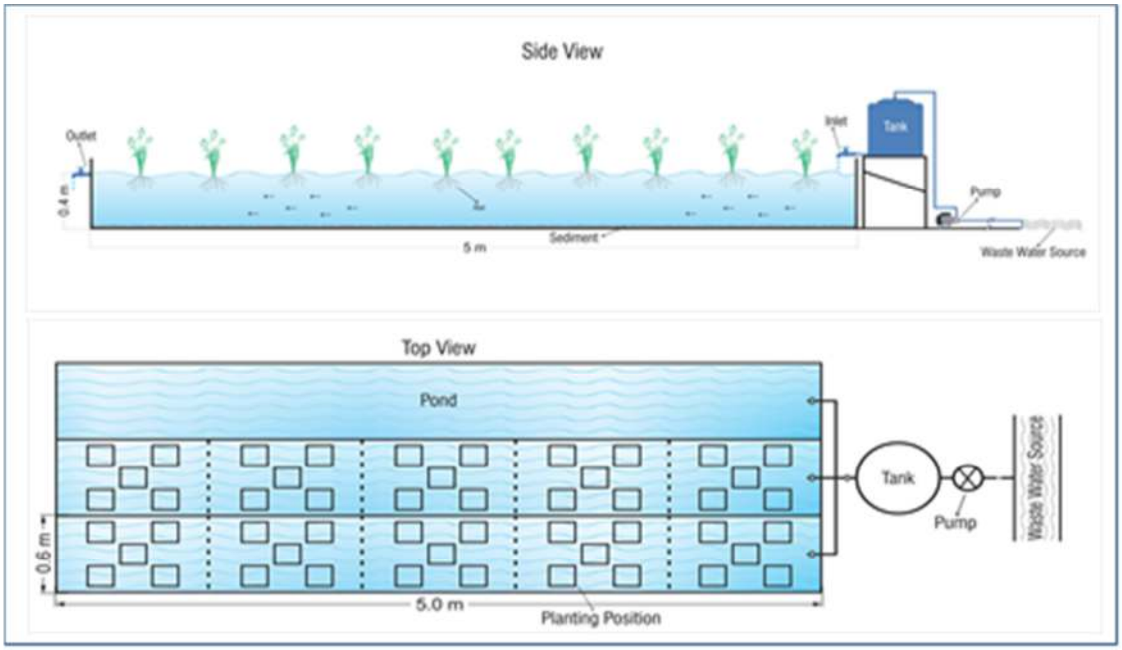

Figure 1. View of Floating Treatment Wetland System (FTWs)

The prepared Constracted Wetlands (CWs) are first filled with domestic wastewater, then each CWs is filled with plants of 5 stems per shoot with 25 shoots per CWs. The plants are acclimated for 1-2 weeks by ensuring the continuous availability of sufficient wastewater in the CWs. After the plants appear to be able to adapt by seeing new root growth, the CWs system can be used for the research process, then fed with new domestic wastewater that has been prepared for the research process continuously at a flow rate of 7 liters/hour.

The sampling process for laboratory tests is carried out every 2 (two) weeks in a row until the 18th week. Influent and effluent wastewater samples (as overflow) were taken in each research pond. Samples of inlet and outlet wastewater were taken and immediately taken to the laboratory to be examined for the main parameters of domestic wastewater.

Results and Discussion

The average temperature and pH of the influent wastewater were 28±4°C and 6.69±0.7, respectively. The effect of plants on water quality was observed as a significant degradation in pH, TSS, BOD and COD (Table 1). The concentration of all the test parameters above was significantly degraded, this shows that the FTW system being tested is functioning well, this cannot be separated from the low Hydraulic Loading Rate (HLR) of around 7 Ltr/hour, which will result in Hydraulic Retention Time (High HRT) makes contact between the roots or rhizofer and wastewater occur perfectly.

The most significant efficiency of reducing domestic wastewater using the FTWs system from the three experimental ponds occurred in ponds with a plant height of T90-150cm, namely pH 6.92; TSS 98.29%; BOD 97.62% and COD 98.79%.

Table 1. Degradation Efficiency (DE) of domestic wastewater parameters in FTWs systems with variations in plant height.

No.	Parameter		pH	TSS (mg/l)	BOD (mg/l)	COD (mg/l)
		Standars	6,5 - 8,5	50	2	10
1.	Control (without plant)	Average DE(%)	7,07	70,55%	44,72%	42,85%
2.	Plants T 50-90cm		6,65	98,27%	97,86%	97,81%
3.	Plants T 90-150cm		7,04	98,29%	97,62%	98,79%
% DE Average			6,92	98,28%	97,74%	98,30%

Temperature, pH, and dissolved oxygen content are parameters that influence the nutrient deconcentration mechanism. This is because the microorganisms and plants that play a role in the deconcentration process are sensitive to these three parameters. The influence of temperature, pH, and oxygen content as observed parameters will be discussed as follows.

Temperature is the degree or level of heat of a substance. Temperature is one of the physical parameters that influences the nutrient deconcentration process in research ponds. The process of exchanging substances (metabolism) in living things is greatly influenced by temperature conditions. Plants can also absorb nutrients well if they are in ideal temperature conditions.

In the pytotreatment test, the temperature for all ponds in this study was around 28 ± 4oC. Because the ponds is placed in an open space with a plastic roof to avoid rain, as a result the sun's rays and heat affect the normal temperature increase. The higher the temperature, the lower the oxygen levels will be, which will cause a decrease in the ability to deconcentrate ammonium using the nitrification process. On the other hand, according to (Jones et al., 2013), the possibility of ammonium volatilization increases at high temperatures (>21oC). High temperatures can also support organic decomposition and/or mineralization (ammonification process) resulting in an increase in ammonium concentrations (Zhang et al., 2016).

Microorganisms that play a role in nitrogen deconcentration depend on temperature conditions. The ideal temperature for the nitrification process ranges from 16.5oC to 32oC and for the denitrification process it ranges from 20oC to 25oC (Saeed & Sun, 2012). During this research, temperature conditions were ideal for the nitrification process, but very supportive for the denitrification process because the temperature was ideal with normal hot sunlight. This can be seen from the very good growth of the *Actinoscirpusgrossus* plant at a temperature of 28 ± 4oC in addition to an adequate supply of wastewater.

The degree of acidity or pH shows the concentration of H+ ions and OH- ions in wastewater water, the higher the H+ ions indicate that the wastewater is acidic and the higher the OH- ions indicate that the wastewater is alkaline.

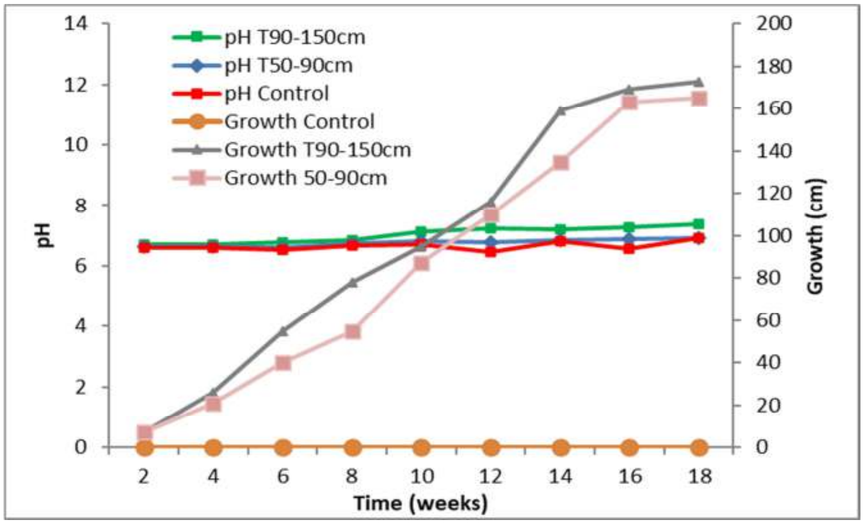

Figure 2. The relationship between the pH of domestic waste and plant growth (Control = no plants; T = plant height; HLT conditions = 7 lt/hour; temperature: 28 ± 4 ^{0}C; per shoot = 5 stems; per pond = 25 shoots)

In Figure 2, the relationship between pH and wastewater plant growth is depicted. pH measurements were carried out each time sampling, the results of pH analysis for each pound variable showed that the pH in the pound effluent fluctuated in the range of 6.61–7.37, where the pH in the control effluent (without plants), plant height was 50-90 cm and plant height was 90 -150 cm respectively with average values of 6.65, 6.76 and 7.03. The effect of pH on plant growth from each pond can be seen in Figure 2. During reactor operation, there was an increase in pH from the initial wastewater or influent to the effluent in the three types of ponds but it was still in the normal range. It can be illustrated that the decrease in pH in all ponds shows that plants begin to absorb N in the form of ammonium. A decrease in pH can also occur due to microbial respiration and plant roots which release CO_2, resulting in an increase in the concentration of carbonic acid or bicarbonate which leads to a decrease in pH.

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It should be noted that when plants absorb N in the form of nitrate, the plants will release hydroxyl ions, causing the rhizosphere to become more alkaline. When plants absorb N in the form of ammonium, the plants will release hydrogen ions so that the pH in the rhizosphere becomes more acidic. Based on this, it can be said that the decrease in pH in each pond is because plants absorb more N in the form of ammonium than nitrate. A relatively stable pH at 6-7 conditions results in the process of absorbing nutrients and nutrients being maximized, resulting in optimum plant growth.

The retention time of domestic wastewater greatly influences the concentration of TSS in domestic wastewater which will be processed by the Actinoscirpusgrossus aquatic plant. In Figure 3, the initial average concentration of wastewater TSS is very high at 1,386 mg/l, organic and inorganic compounds will form sedimentation at the bottom of the CWs pond and will be decomposed by microbes in the roots of the *Actinoscirpusgrossus* plant.

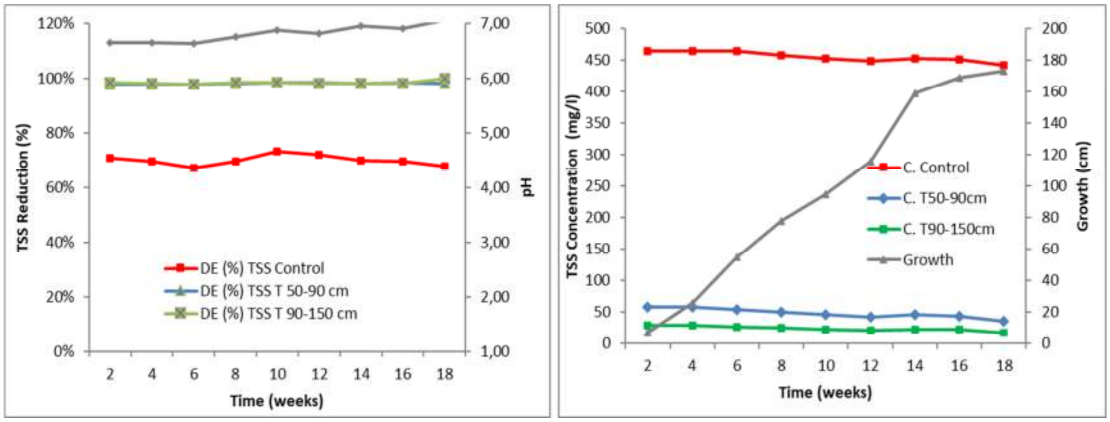

Figure 3. Degradation of TSS in domestic wastewater (A). TSS Degradation Efficiency (B). Degradation of TSS on plant growth (Control = no plants; DE = degradation efficiency; T = plant height; HLT conditions = 7 lt/hour; temperature: 28 ± 4 ^{0}C; per shoot = 5 stems; per pond = 25 shoots)

Figure 3 it can be seen that the filtration process by roots and sedimentation due to HRT really helps reduce the TSS concentration to below the quality standard of 50 mg/l. It can be seen that the average TSS degradation efficiency (DE) can reach 98.43% (average Cinf 1,386 mg/l and average Ceff 23.11mg/l) at plant height with T 90-150cm and 98.22% (average Cinf 1,386 mg/l and average Ceff 24.11mg/l) at T 50-90cm compared to the control pound of 70.09% (average Cinf 1,386 mg/l and average Ceff 406, 94mg/l), so it can be said that pond installation can increase the efficiency of reducing TSS parameters very significantly.

The decrease in TSS after processing using aquatic plants has previously been reported by other researchers (Vymazal, 2011) due to the porosity of the filter media roots of the aquatic plant *Actinoscirpusgrossus*. Microorganisms and dense root systems and long HRT times are these factors which greatly influence the degradation in TSS, roots with dense fibers will allow suspended particles in wastewater water to stick to the roots of aquatic plants. Degradation of TSS will affect the COD and BOD content values (Vymazal, 2011) and (Tanaka et al., 2006).

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The decrease in the concentration of organic matter in constructed wetlands systems occurs due to the mechanism of microorganism and plant activity, through the oxidation process by aerobic bacteria that grow around the plant rhizosphere or the presence of heterotrophic bacteria in wastewater.

In Figure 4 you can see the BOD allowance for ponds planted with plants with a height of T 50-90cm and T 90-150cm and without plants. The average BOD DE can reach 97.62% (average C_{inf} 66.88 mg/l and average C_{eff} 1.50 mg/l) at plant height with T 90-150cm and 97.86 % (average Cinf 66.88 mg/l and average Ceff 1.40 mg/l) at T 50-90cm compared to the control pond of 45.92% (average Cinf 66.88 mg/l and The average Ceff is 36.68 mg/l), the effluent standard is 2 mg/l, so it can be said that plant installation can increase the efficiency of removing BOD parameters.

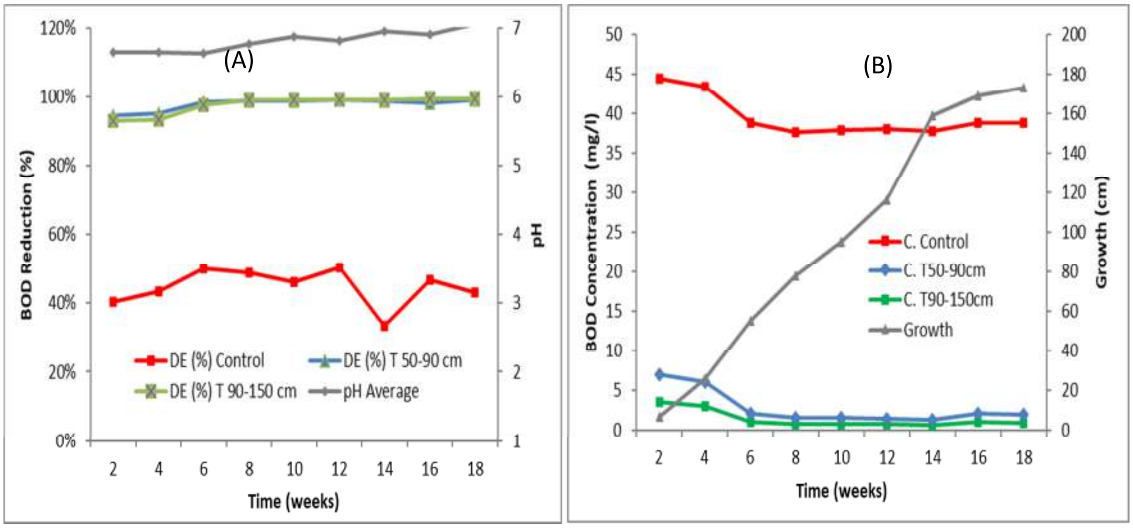

Figure 4. Degradation of BOD in domestic wastewater (A). BOD Degradation Efficiency (B).Degradation of BOD on plant growth (Control = no plants; DE= Degradation efficiency; T = plant height; HLT conditions = 7 lt/hour; temperature: 28 ± 4 ^{0}C; per shoot = 5 shoots; per pond = 25 shoots)

The results, it was found that processing with this plant installation was able to reduce BOD pollutant parameters by around 97.82%. This is also confirmed by several research results which show that the efficiency of this system in reducing levels of liquid wastewater pollutants is quite high, according to (Luederitz et al., 2001) in Einsdorf this system can reduce BOD levels to a removal percentage of 95%, while in Wolfsberg the removal percentage reaches 99%. Research at other locations also shows that processing with this plant installation has a BOD degradation efficiency of 90-97%, where BOD removal occurs through aerobic and anaerobic processes.

Aerobic processes occur in the area around the roots, while anaerobic processes occur in supporting media layers such as the formed sedimentation, soil and sand. The high efficiency is also due to cooperation between the components in the installation, where the plants supply oxygen to the root area and are supported by microorganisms found in the sidementation layer, soil and sand.

The same thing was also obtained in reducing COD, as shown in Figure 5, where the installation of ponds with plants was able to produce an average COD degradation efficiency (DE) of 98.79% (average Cinf 176.56 mg/l and Average C_{eff} 2.15 mg/l) at plant height with T 90-150cm and 97.81% (average Cinf 176.56 mg/l and average Ceff 3.84 mg/l) at T 50 -90cm compared to the control pound of 42.85% (average Cinf 176.56 mg/l and average Ceff 100.67 mg/l), standard effluent volume of 10 mg/l.

The presence of plants in the installation can increase the efficiency of the degradation very significantly. The results of research (Catharina et al., 2013) using the same system but with different plants showed that COD levels could be reduced by around 95–99%.

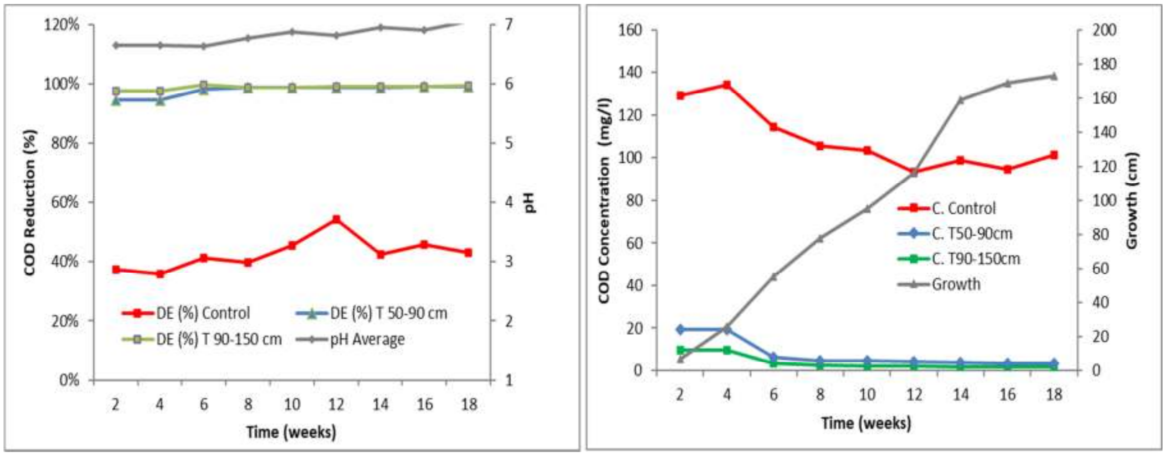

Figure 5. Degradation of COD in domestic waste (A). COD Degradation Efficiency (B). Degradation of COD on plant growth (Control = no plants; DE= Degradation efficiency; T = plant height; HLT conditions = 7 lt/hour; temperature: 28 ± 4 ^{0}C; per shoot = 5 shoots; per pond = 25 shoots)

In Figure 5 it can be seen that the effluent results for processing without plants show that the removal percentage is quite far compared to installations using plants for an HLR of 7 lt/hour. If the processing uses plants, you can get a very significant difference in the removal distance compared to without using plants. The presence of processing with plant installations can increase removal efficiency by an average of 54.96-55.93% higher than without plants.

The high degradation efficiency achieved with plant installations is due to the process of plant respiration, where aquatic plants supply oxygen from the air through their stems, stem leaves, roots and rhizomes which are then released back into the root area, a process occurs in the rhizosphere area which is aerobic in nature allowing various activities. bacteria decompose polluting organic materials, apart from that it is also supported by the sediment layer where these materials are absorbed in the sediment layer, so that in the end it will form new biomass for plants, as gas into the atmosphere and as clean water. As with BOD removal, increasing HLR will reduce removal efficiency.

Conclusion

The results that have been concluded are as follows:

1. The ability to degrade the main wastewater parameters by the aquatic plant *Actinoscirpusgrossus* shows very good results.
2. The results of the experimental parameter test were obtained with an average degradation efficiency (% DE), namely TSS 98.28%; BOD 97.77% and COD: 98.30% at an average pH of 6.92.
3. Design/operational characteristics for a continuous system with an HLR of 7 ltr/hour and an HRT of 5.98 days with a pound volume of 1 M^3, pound size LxWxH; 5.0mx0.6mx0.4m, plant planting; 5 stems/shoot and 25 shoots/pound, all of these characteristics are able to degrade the main wastewater parameters significantly.

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