© JUL 2025 | IRE Journals | Volume 9 Issue 1 | ISSN: 2456-8880

Comparative Analysis of Water Hyacinth and Scurvy Weed for Treatment of Brewery Wastewater in Kaduna

SAHEED OLADELE OLUSUPO[1], RABIAH LAWAL BATAGARAWA[2], ETIM CYRIL[3], VIVIEN CHIKOGU AMESO[4], GRACE BINBOLA OGUNLEYE[5]

[1, 2, 3, 4, 5]*Nigerian Defense*

Abstract-* Macrophytes have emerged as a cost-effective, eco-friendly and sustainable solutions to enhance water quality by effectively removing nutrients. The study focused on assessing the effectiveness of water hyacinth and scurvy weed for the treatment of brewery wastewater in Kaduna. Three artificial wetlands (for water hyacinth, scurvy weed, and both plants combined) were developed, each measuring 0.43 m by 0.93 m by 0.36 m in width, length, and depth, respectively, to replicate natural conditions. The percentage removal of various parameters, including pH, Total Dissolved Solids (TDS), Turbidity, Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphorus, Nitrate, Ammonia, Sulphate, Copper, Zinc, Iron and Lead were analysed. The result showed that water hyacinth was more effective in reducing 31% pH, 66% EC, 66% TDS, and 100% copper while scurvy weed was more efficient in reducing 99% Turbidity, 79% COD, 77% BOD. The set up of the two plants combined performed more effectively in reducing (100%) zinc similar to water hyacinth and (93%) sulphate similar to scurvy weed. All the setups were effective in reducing Ammonia, Nitrate and Total Phosphorus by 100%. The result showed that all the considered parameters were all within the allowable range/limit of NESREA under National Environmental (Food, Beverage and Tobacco sector) regulation 2023

***Indexed Terms-* Brewery Wastewater, Kaduna, Macrophytes, Scurvy Weed, Water Hyacinth**

I. INTRODUCTION

Water supply is steadily decreasing due to several causes, while water consumption increases in tandem with population expansion. Contamination of existing water bodies is the primary source of the freshwater deficit. There are numerous approaches to wastewater treatment and management. Conventional and natural remedies have been developed. The necessity of a centralized effluent collecting system for these conventional treatment facilities raises questions regarding their feasibility in isolated locations with sparse populations (Wickramasinghe & Jayawardana, 2018). Wastewater can be treated using physical, chemical, biological, or combinations of these methods, depending on the required output criteria. Ogunbodede et al. (2022) claims that natural treatment procedures that utilize resources found in plants, soils, and related microbiological components can reduce and remove contaminants in wastewater. The two categories are land treatment systems and aquatic treatment systems (Siswoyo et al., 2019). Aquatic plants have been used as a wastewater treatment approach in many different contexts worldwide, along with management approaches for the treatment of residential, commercial, and industrial wastewaters. One location where this treatment technology has been effectively applied is the Koele Golf Course on the Hawaiian island of Lanai, where treated wastewater has been used for irrigation since 1994 (Dadi-mamud et al., 2020).

Phytoremediation is an alternative wastewater treatment technique that is being studied all over the world. It offers a lot of promises for treating wastewater in comparison to more conventional methods such as trickling filters, sequential batch reactors, up-flow anaerobic sludge blankets, activated sludge processes, etc. (Ajibade & Adewumi 2017). Phytoremediation is a technique used by green plants (Macrophytes) to convert pollutants into harmless forms (Badejo et al., 2022). Because phytoremediation methods use natural plants, it is both economical and environmentally safe. It is a solar-powered, in-place therapeutic approach (Kinidi & Salleh 2017).

Created wetlands are the most popular type of phytoremediation technique (Tamara and Paul, 2019). To be treated by aquatic plants, wastewater must be directed into swamplands or other artificially or naturally formed aquatic plant habitats. The plants are the most crucial component of this system. The oxygen supply of the roots facilitates the decomposition of organic materials, the uptake of nutrients and heavy metals by microorganisms, filtration, chemical precipitation, sedimentation, microbial decomposition, and other biological processes (Amarea et al. 2018). It can treat almost any type of wastewater, including municipal, industrial, and residential wastewater (Agarry et al. 2018). For phytoremediation to be successful, a plant with a high rate of pollution uptake and the ability to flourish in wastewater must be selected (Magar et al. 2017). To be treated by aquatic plants, wastewater must be directed into swamplands or other artificially or naturally formed aquatic plant habitats.

El-Chaghaby et al. (2022) examined the possible applications of water hyacinth and invasive aquatic weeds, while Abdullahi et al. (2024) evaluated the physicochemical parameters from a hospital wastewater treatment plant in Zaria using a standard method for water and wastewater examination and its phytoremediation by hydroponic treatment method using Vetiveria zizanoides (Vetiver grass), Pistia stratiotes (Water lettuce), and Eichhornia crassipes (water hyacinth).

However, there remain paucity of studies on the analysis of water hyacinth and scurvy weed for treatment of brewery wastewater

Scurvy Weed (Commelina Cyanea)
Scurvy weed, or Commelina Cyanea, is a perennial herb that grows naturally in the damp forests and woodlands of Norfolk Island, Lord Howe Island, and eastern Australia., the plant, which is a member of the Commelinaceae family, has blue blooms that bloom during the warmer months and are pollinated by flies and bees. Commelina are naturally occurring coagulants that can be effective clarifying agents and reveal their potential as materials for flocculation and coagulation procedures that clarify water (Gampel, 2003). The very waterlogged soils surrounding wetlands are home to Commelina cyanea. Often confused with Trandescantia fluminensis, it is distinguished by its narrower leaves and bright blue (instead of white) flowers. Its fleshy stems can reach a length of 1-2 meters, and its leaves are 2-7 centimeters long and 5-15 millimeters wide. Through coagulation and flocculation processes, commelina, which are natural coagulants, can be utilized as effective clarifying agents and reveal their potential as materials for water clarification (Haryanto et al., 2020).

Fig. 1: Commelina Cyanea

Water Hyacinth (Eichhornia crassipes)
The aquatic weed known as water hyacinth (Eichhornia crassipes) is indigenous to South America. However, it is frequently described to as the poisonous beauty because to its stunning purple blossoms. It can be anchored in mud or float freely on the surface of freshwater to live and procreate. It spreads rapidly throughout temperate, tropical, and sub-tropical regions and is undoubtedly one of the most poisonous aquatic weeds. (Dagno et al., 2007). It has become a problem in all continents apart from Europe. Water hyacinth grows over a wide variety of wetland types such as lakes, streams, ponds, waterways, ditches and backwater areas in temperate and tropical zones (Ndimele, 2012). Water hyacinths reproduce mostly by producing stolons or runners that eventually develop into daughter plants. Additionally, each plant has the capacity to yield thousands of seeds annually, which can survive for over 28 years. Mats of common water hyacinths (Pontederia crassipes) can double in size in just one to two weeks due to their fast growth. They are

claimed to multiply by more than a hundredfold in just 23 days, based on the quantity of plants rather than their size. Water hyacinth is commonly considered an invasive plant because of its ability to grow quickly and produce dense mats on the surface of water bodies (Ogunbodede et al., 2022). Fish kills and other negative ecological effects could result from these mats' potential to block sunlight from indigenous aquatic plants and reduce water oxygen levels. The common water hyacinth, or Eichhornia crassipes, is a hardy plant that can double in size in just two weeks. Additionally, harmful metals and other contaminants can be removed from aquatic ecosystems with its promising potential (Adelodun et al., 2021). Water hyacinth has various uses despite its propensity for invasion. Because of its low lignin content and high biomass production rate, it can be utilized as a feedstock for biofuel and is employed as a bioindicator for heavy metal pollution in water bodies (Koupai et al., 2009).

Fig. 2: Water Hyacinth

Scurvy weed for Water Treatment

Ajibade & Adewumi (2017) In Akure evaluated the phytoremediation potential of three aquatic macrophytes (Commelina cyanea, Phragmites australis and Water Hyacinth (Eichhornia crassipes)) for treatment of municipal wastewater collected from the Federal University of Technology, Akure (Nigeria). Laboratory scale of three constructed wetlands of dimensions 0.43m x 0.93m x 0.36m in width, length and depth respectively, a single experimental run with each macrophyte at different retention time of 6, 9 and 12 days. The raw wastewater sample and treated wastewater samples were analysed for (Turbidity and Dissolved solids), chemical (pH, Nitrate, Nitrite, Phosphate, Sulphate Chemical Oxygen Demand and Biochemical Oxygen Demand) and bacteriological (Coliform bacteria) parameters. Results showed the three plants effectively removing Nitrate, Nitrite, phosphate and Sulphate pollutants, Phragmites australis gave the highest removal efficiency for Phosphate (85.8%), Water hyacinth gave the highest removal efficiency for pH (11.5%), Biochemical Oxygen Demand and Coliform bacteria and Commelina cyanea gave the highest removal efficiency for turbidity (96.9%) and dissolved solids (82.9%) parameters of the domestic wastewater samples

Water Hyacinth for Water Treatment

The ability of water hyacinth to absorb heavy metals from water makes it a promising solution for cleaning up contaminated areas. Ag, Cd, Cu, Pb, Sb, Sn, and Zn were successfully absorbed and translocated from an e-waste recycling site by water hyacinth, demonstrating its capacity to remove heavy metals from water (Du et al., 2020).

According to Sarkar et al. (2017), water hyacinth shoot powder was able to extract 98.83% and 99.59% of copper and chromium, respectively, from a tannery effluent.

El-Din & Aziz (2018) in Egypt Examined the potential uses of growing aquatic plants for wastewater purification on laboratory scale in batch experiments. These aquatic plants, duckweed, water hyacinth and green algae (Chlorella vulgaris). Chemical oxygen demand (COD) and biological oxygen demand (BOD5) reduced in wastewater to (43% and 42%) by duckweeds, (28% and 33%) by water hyacinth, and (33% and 38%) by green algae for 21 days. Duckweeds have much higher pollutants removal efficiencies, especially, N, P, K and other heavy metals than water hyacinth and green algae.

According to Rezania et al. (2016), water hyacinth was effectively utilized to treat household wastewater and lower levels of chemical oxygen demand, phosphate, nitrate, ammonical nitrogen (NH3), and total organic carbon. In China, water hyacinth was used to remove nutrients on a massive scale (Wang et al., 2012). Additionally, water hyacinth had the maximum removal efficiency for ammonia (99.0%)

and total nitrogen (89.4%) from contaminated rural rivers, efficiently eliminating surplus nutrients (Lu et al., 2018). Additionally, the viability of using water hyacinth to treat formaldehyde in wastewater was demonstrated, and the plant's development was successfully managed (Gong et al., 2018).

Saha et al. (2017) in India examined the phytoremediation potential of Water hyacinth to treat toxic hexavalent chromium (Cr VI) contamination from wastewater of chromite mines. It was found that Water hyacinth removed 99.5% Cr (VI) of processed water in just 15 days. Similar efficiency was achieved in a large-scale experiment using 100 liters of the same wastewater

Adelodun et al., (2021) in Akure used live water hyacinth Water (Eichornnia crassipes) to purify effluents from textile factories and monitored changes in the physicochemical properties, organic pollutants, and Water Hyacinth biomass. It achieved 55, 91, 53, 84, 96, 53, and 55% removal efficiency for total Kjeldahl-N (tK-N), NH3–N,organic-N, PO43–,SO42–,Cl–, and hardness, respectively. Likewise, the biomass growth showed a positive and strong correlation with NH3-N (0.998), tK-N (0.956), organic-N (0.923), pH (0.853), and EC (0.712). In contrast, chemical oxygen demand and total oil and grease (TOG) evinced negative and strong correlations of 0.994 and 0.807, respectively. Further, Cl–correlated mildly (–0.38), while alkalinity (0.154) and water hardness (–0.296) were less influential on the biomass growth

Rezania et al. (2016) in Malaysia Studied the use of water hyacinth (Eichhornia crassipes) to treat domestic wastewater. Ten organic and inorganic parameters were monitored in three weeks for water purification. The six chemical, biological and physical parameters included Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), chemical oxygen Demand (COD), Ammoniacal Nitrogen (NH3-N), Total Suspended Solids (TSS), and pH were compared with the Interim National Water Quality Standards, Malaysia River classification (INWQS) and water Quality Index (WQI). Between 38% to 96% of reduction was observed. Ammoniacal nitrogen was reduced by 64%, COD reduced by 41%, BOD reduced by 61%, DO improved by 47%, TSS reduced by 34%.

II METHODOLOGY

Laboratory Setup

Each pond is made of a plastic container Containers of dimension 0.43m X 0.93m X 0.36m and the setup will be like Ajibade et al., (2017). Three setups were made each for water hyacinth, scurvy weed, and water hyacinth and scurvy weed combined. The ponds were filled first with coarse aggregates (granite), then with soil before planting the macrophytes. The plants were cultivated for a month and half before wastewater was introduced.

Fig 3: pond setup

Fig 4; cultivated plant

Fig.5: sample collection

Sample Collection/Analysis

Wastewater samples of the pond's effluent were collected from each pond of water hyacinth, scurvy weed and water hyacinth and scurvy weed combined through the tap. Sample were taken as described by Rezainia et al., (2016), at 4days interval for 21 days. American Public Health Association's standard method for water and wastewater examination was adopted (APHA, 2012). The values of the removal efficiency were calculated using Equation 1. Table 1 outlines the analytical methods and instruments used to analyse each parameter in this study. The Removal Efficiency (R.E) is given as:

$$R.E\ (\%) = \frac{Ci - Ce}{Ci} \times 100 \qquad (1)$$

Where:

Ci = Concentration of influent (mg/L).

Ce = Concentration of effluent (mg/L).

III. RESULTS AND DISCUSSION

pH Reduction Efficiency Over Time

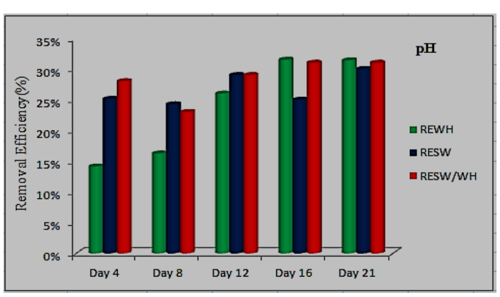

Fig.6: pH reduction efficiency

The pH of untreated wastewater was 10.35, indicating highly alkaline conditions. Over the course of treatment, Water Hyacinth, Scurvy Weed and the combine plants system significantly reduced the pH, 7.1, 7.2 and 7.1 respectively bringing it closer to the NESREA standard range of 6.5-8.8. Water Hyacinth achieved a removal efficiency of 31% and Scurvy Weed achieved a slightly lower removal efficiency of 30% on the 21st day. This demonstrates that both plants were highly effective in reducing the alkalinity of the wastewater. Previous studies by Kumar et al. (2018) found similar reductions in industrial wastewater treated with Water Hyacinth, which reduced pH by approximately 35% while the combine plants treatment system had same removal efficiency as water hyacinth (31%)

Electrical Conductivity (EC) Reduction Efficiency over Time

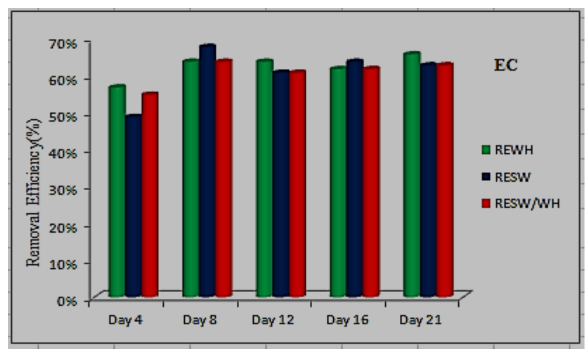

Fig.7: EC reduction efficiency

The Electrical Conductivity (EC) of untreated wastewater was 1636 µS/cm, which exceeds the NESREA limit of 1000 µS/cm. After 21 days of treatment, the EC levels were significantly down. Water Hyacinth brought the EC to 550 µS/cm, achieving a removal efficiency of 66%, Scurvy Weed reduced the EC to 590 µS/cm, with a removal efficiency of 63%, a removal efficiency of 63% was also achieved for the combine plants system. Water Hyacinth proved more efficient, and this aligns with previous studies by Alam et al. (2016), who found that Water Hyacinth could reduce EC in wastewater by up to 75%, highlighting its strong ion removal capacity.

Total Dissolved Solids (TDS) Removal Efficiency over Time

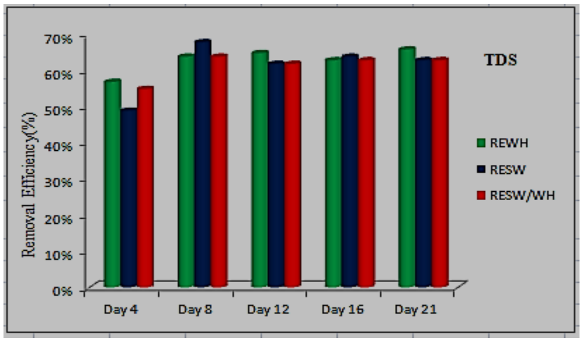

Fig.8: TDS removal efficiency

The TDS of untreated wastewater was 820 mg/L, exceeding the NESREA standard of 500 mg/L. Over the 21-day treatment period, Water Hyacinth, Scurvy Weed and the combine system showed strong TDS reduction. Water Hyacinth reduced TDS to 279 mg/L, achieving a removal efficiency of 66% (Table 4.1), Scurvy Weed reduced TDS to 300 mg/L, achieving a removal efficiency of 63% and same removal efficiency achieved for the combine plants system as shown and illustrated These findings align with Siswoyo et al. (2019), who noted that Water Hyacinth had excellent performance in TDS reduction due to its ion absorption capabilities

Total Suspended Solids (TSS) Removal Efficiency over Time

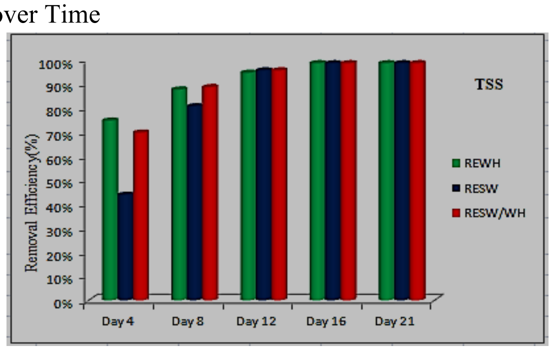

Fig.9: TSS removal efficiency

The untreated wastewater had a TSS concentration of 528 mg/L, far exceeding the NESREA standard of 50 mg/L. Both Water Hyacinth and Scurvy Weed showed excellent TSS reduction throughout the treatment period. Water Hyacinth reduced TSS to 7 mg/L. Scurvy Weed reduced TSS to 5 mg/L, the combine system reduced the TSS to 3 mg/L all with a removal efficiency of 99%. The treated water meets the NESREA standards for suspended solids, making it suitable for discharge.

Nitrate Removal Efficiency over Time

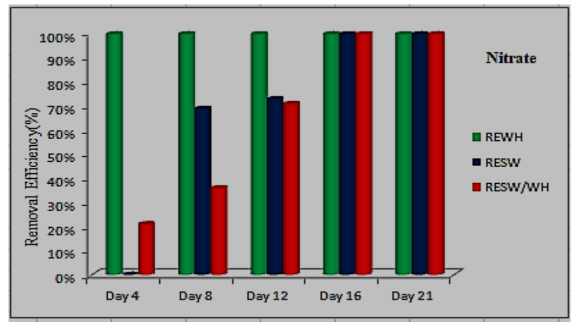

Fig.10: Nitrate removal efficiency

The nitrate content in the raw effluent was 3.3 mg/L, water hyacinth reduced the nitrate content to 0.00 mg/L with a removal efficiency of 100%. Scurvy weed and combine plants system also achieved removal efficiency of 100% reduction to 0.00mg/L

Ammonia Removal Efficiency over Time

The untreated sample had an ammonia concentration of 5.3 mg/L, exceeding the NESREA limit of 1.0 mg/L. After treatment, Water Hyacinth and the other two setups completely removed ammonia reaching 0.00 mg/L Badejo et al., (2022) and Du et al. (2020), also found that Water Hyacinth removed ammonia from industrial wastewater within a similar timeframe, reducing concentrations from 4.8 mg/L to 0.00 mg/L.

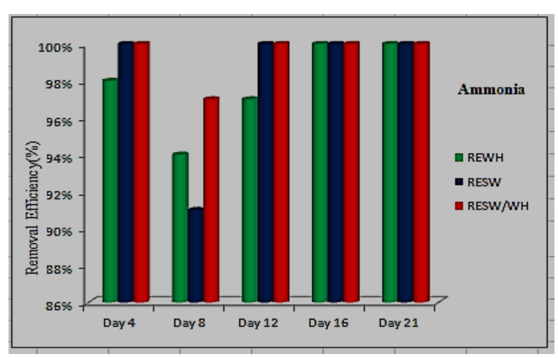

Fig.11: Ammonia removal efficiency

Sulphate Removal Efficiency over Time

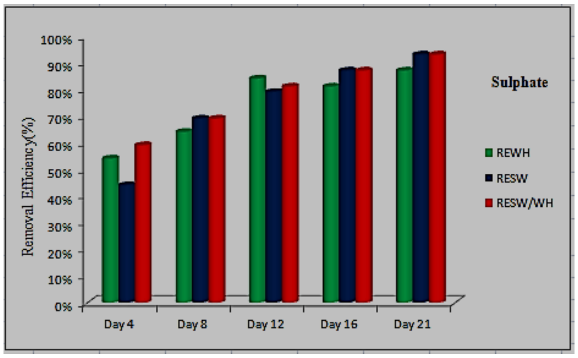

Fig.12: Sulphate removal efficiency

In the untreated sample, sulphate was measured at 70 mg/L, which is below the NESREA standard of 290 mg/L. Water Hyacinth, Scurvy Weed and Scurvy Weed with Water Hyacinth (combine plants treatment system), effectively reduced sulphate levels on the 21st day to 9 mg/L, 5mg/L and 5mg/L with removal efficiency of 87%, 93% and 93%.

Total Phosphorous (TP) Removal Efficiency over Time

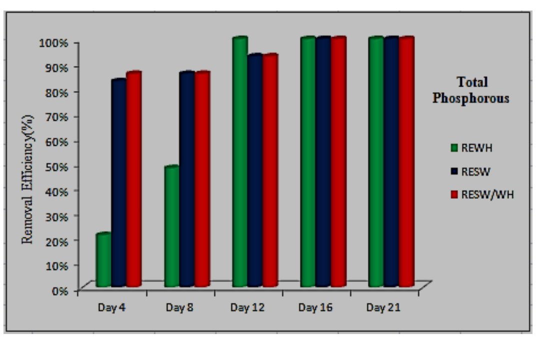

Fig.13: Total Phosphorus removal efficiency

Total phosphorus was measured at 0.29 mg/L in the untreated sample, which was below the NESREA standard of 2.0 mg/L. Water Hyacinth, Scurvy Weed and Scurvy Weed with Water Hyacinth (combine plants system), effectively reduced total phosphorus levels to undetectable with removal efficiency of 100% for all systems as shown in the analysis Table 2, The results here are consistent with Zhou et al., (2020) report for water hyacinth which reduced total phosphorus wastewater to undetectable levels.

Biological Oxygen Demand (BOD) Removal Efficiency over Time

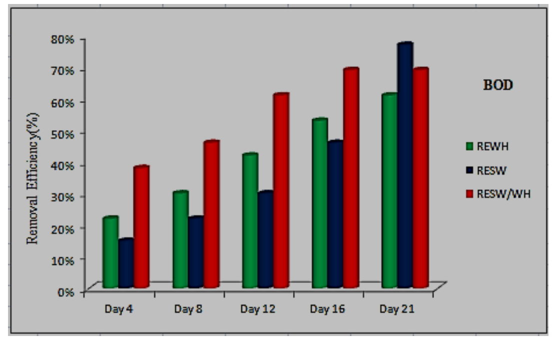

Fig.14: BOD removal efficiency

The untreated wastewater had a BOD of 25.8 mg/L, slightly below the NESREA standard of 30 mg/L. Both Water Hyacinth and Scurvy Weed showed strong efficiency in reducing BOD levels These results align with those of Abdullahi et al. (2024), who observed similar BOD reductions in wetlands treated with macrophytes. Water Hyacinth achieved a removal efficiency of 61%, Scurvy Weed achieved a slightly higher removal efficiency of 77%, the combine plants treatment system had a removal efficiency of 69% showing that scurvy weed performs better amongst the systems.

Chemical Oxygen Demand (COD) Removal Efficiency over Time

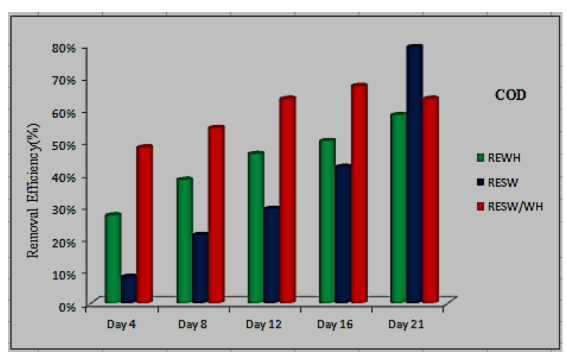

Fig.15: COD removal efficiency

The untreated wastewater had a COD of 48 mg/L, below the NESREA standard of 60 mg/L. Both plants showed considerable efficiency in COD reduction, with scurvy weed achieving higher removal rates by the end of the experimental period. However, Water Hyacinth reduced the COD to 20 mg/L, achieving a removal efficiency of 58%. Scurvy Weed reduced the COD to 10 mg/L, with a removal efficiency of 79% while the combine plants treatment system reduced the COD to 18 mg/L with a removal efficiency of 63%.

Iron Removal Efficiency over Time

The iron concentration in untreated wastewater was 14.2 mg/L, which is well above the NESREA limit of 3.0 mg/L. Water Hyacinth, Scurvy Weed, and the combine plants treatment system reduced iron concentrations significantly over the treatment period. Water Hyacinth reduced iron to 0.21 mg/L, achieving a removal efficiency of 99%, while the Scurvy Weed, and the combine plants treatment system reduced iron to 0.07 mg/L and 0.06 with achieving a removal efficiency of 100% respectively. These findings are consistent with Reddy et al. (2015), who observed similar iron removal efficiencies in wastewater treated with Water Hyacinth

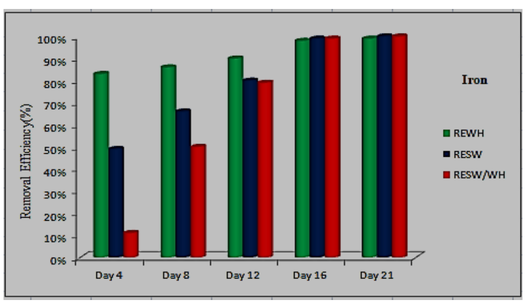

Fig.16: Iron removal efficiency

Copper Removal Efficiency over Time

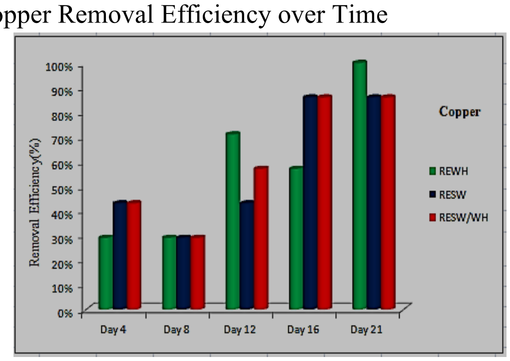

Fig.17: Copper removal efficiency

Copper concentrations in the untreated wastewater were low (0.007 mg/L), below the NESREA limit of 0.5 mg/L. However, both plants in the single systems and the Combine plants system were still able to reduce copper concentrations further (Wimalarathne & Perera, 2019). Water Hyacinth reduced copper to 0.000 mg/L achieving a removal efficiency of 100%, whereas the Scurvy Weed and the combine plants treatment system, both reduced copper to 0.001 mg/L, achieving a removal efficiency of 86%.

Zinc Removal Efficiency over Time

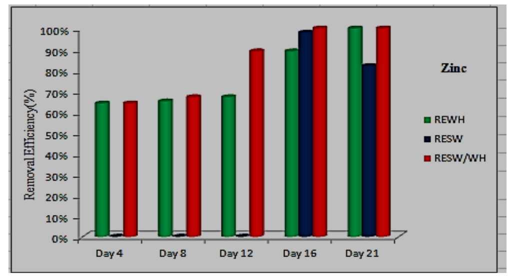

Fig.18: Zinc removal efficiency

Zinc is another heavy metal present in the untreated wastewater at a concentration of 5.69 mg/L, above the NESREA limit of 2.0 mg/L. Both plants in the single plants systems and in the combine plants treatment system showed strong performance in reducing zinc concentrations. Water Hyacinth completely removed zinc from the wastewater, while Scurvy Weed and the combined plants system also showed high efficiency in reducing the zinc concentration in the wastewater (Zhang et al., 2020). The results align with Reddy et al. (2015), who reported similar findings with Water Hyacinth in zinc-contaminated waters. From findings summary in table 2 Water Hyacinth reduced zinc to 0.00 mg/L achieving a removal efficiency of 100% as while Scurvy Weed reduced zinc to 1.01 mg/L, achieving a removal efficiency of 82% and the combine plants treatment system having a removal efficiency of 100%.

CONCLUSION AND RECOMMENDATIONS

This study conducted a comparative analysis of water hyacinth and scurvy weed for the treatment of brewery wastewater in Kaduna. The findings indicated that water hyacinth achieved a removal efficiency of 66% for electrical conductivity (EC), 66% for total dissolved solids (TDS), and 100% for copper. In contrast, scurvy weed effectively reduced turbidity by 99%, chemical oxygen demand (COD) by 79%, and biological oxygen demand (BOD) by

77%. While both plants were utilized together, they demonstrated significant efficacy in reducing total suspended solids (TSS) by 99%, sulfate by 93%, zinc by 100%, and iron by 100%. All setups successfully eliminated Ammonia, Nitrate, and Total Phosphorus by 100%, all of which were within the permissible limits established by NESREA under the National Environmental (Food, Beverage and Tobacco Sector) Regulation 2023. This paper advocates for the utilization of macrophytes in wastewater treatment in Nigeria. Industries ought to utilize macrophytes for wastewater treatment prior to discharge into surface water, as this method is efficient, cost-effective, and environmentally sustainable.

Table 1: Summary of findings

Parameter	Untreated	WH	R.EWH	SW	R.ESW	SW/WH	R.ESW/WH	NESREA Standard
pH	10.35	7.1	31%	7.2	30%	7.1	31%	6.5-8.8
Turbidity (NTU)	294	2.57	99%	1.99	99%	1.99	99%	5.0
EC (µS/cm)	1636	550	66%	601	63%	601	63%	1000
TDS (mg/L)	820	279	66%	300	63%	300	63%	500
TSS (mg/L)	528	7	99%	5	99%	3	99%	50
Ammonia (mg/L)	5.3	0	100%	0	100%	0	100%	1.0
Nitrate (mg/L)	3.3	0	100%	0	100%	0	100%	10
Sulphate (mg/L)	70	9	87%	5	93%	5	93%	290
Total Phosphorus (mg/L)	0.29	0	100%	0	100%	0	100%	2.0
COD (mg/L)	48	20	58%	10	79%	18	63%	60
BOD (mg/L)	25.8	10	61%	6	77%	8	69%	30
DO (mg/L)	0.026	0.026	0%	0.026	0%	0.026	0%	>2.0
Iron (mg/L)	14.2	0.09	99%	0.07	100%	0.06	100%	3.0
Zinc (mg/L)	5.69	0	100%	1.01	82%	0	100%	2.0
Lead (mg/L)	0	0	****	0	****	0	****	0.05
Copper (mg/L)	0.007	0	100%	0.001	86%	0.001	86%	0.5

Quality from Water Hyacinth (WH), Scurvy Weed (SW) and Scurvy Weed with Water Hyacinth (SW/WH) removal efficiency water hyacinth(R.EWH), removal efficiency Scurvy weed(R.ESW), removal efficiency Scurvy weed with Water Hyacinth (R.ESW/WH), (BOD): Biological oxygen demand, (COD): Chemical oxygen demand,(DO)-

dissolved oxygen, Electric conductivity (EC), Total Dissolved Solid (TDS), Todal Suspended Solids (TSS), Not Available (****)

REFERENCES

[1] Abdullahi, F. A., Muhammad, M. N. & Abdullahi, S. A. (2024). Evaluation of Eichhornia crassipes, Pistia stratiotes and Vetiver zizanoides in Phytoremediation of a Hospital Wastewater Effluent. Sahel Journal of Life Sciences FUDMA, 2(1): 185-194. DOI: https://doi.org/10.33003/sajols-2024-0201-023

[2] Adelodun, A.A., Olajire, T., Afolabi, N.O., Akinwumiju, A.S., Akinbobola, E. & Hassan, U. O. (2021). Phytoremediation potentials of Eichhornia crassipes for nutrients and organic pollutants from textile wastewater. Int. J. Phytoremed., 3: 1-9.

[3] Agarry, S.E., Oghenejoboh, K.M., Latinwo, G.K. & Owabor, C.N. (2018). Biotreatment of petroleum refinery wastewater in vertical surface-flow constructed wetland vegetated with Eichhornia crassipes: lab-scale experimental and kinetic modeling. Environ. Technol., 41(14):1793- 1813. https://doi.org/10.1080/09593330.2018.1549106

[4] Ajibade, F.O. & Adewumi, J. R. (2017). Performance evaluation of aquatic macrophytes in a constructed wetland for municipal wastewater treatment. FUTAJEET, 11(1) :01-11.

[5] Alam, M. J., & Islam, M. S. (2016). Reduction of electrical conductivity in wastewater using water hyacinth. Journal of Environmental Management, 182, 187-191. https://doi.org/10.1016/j.jenvman.2016.07.023

[6] Amarea, E., Kebedeb, F. & Mulatc, W. (2018). Wastewater treatment by Lemna minor and Azolla filiculoides in tropical semiarid regions of Ethiopia. Ecol. Eng., 120: 464-473. https://doi.org/10.1016/j. ecoleng.2018.07.005

[7] Badejo A.A., David, A.O., Olaniyan, O.S., Opafola, O.T., Amusan, G.M., Orogbade, B.O., Ogundele, S.A., Ajayi, T.A. & Arikewuyo, A.A. (2022). Sequential Treatment of Brewery Effluent using Vegetated Subsurface and Surface Flow Constructed Wetland. UNIOSUN Journal of Engineering and Environmental Sciences. Vol. 4 No. 2.

[8] Dadi-mamud, N. J., Paiko, M. A., Aliyu, A. D., Chiwendu, A. M. & Juliana J. (2020). Assessment of Eichhornia crassipes (Water Hyacinth) as Bio-accumulator of Contaminants in Domestic Wastewater of Makera and Chanchaga Drains. Science World Journal Vol. 15(No 3).

[9] Dagno, K., Lahlali, R., Friel, D., Bajji, M., & Jijakli, H. (2007). Review: Problems of the water hyacinth, Eichhornia crassipes in the tropical and subtropical areas of the world, in particular its eradication using biological control method by means of plant pathogens. Biotechnol. Agron. Soc. Environ., 11(4), 299–311.

[10] Du, Y.; Wu, Q.; Kong, D.; Shi, Y.; Huang, X.; Luo, D.; Chen, Z.; Xiao, T. & Leung, J. Y. S. (2020). Accumulation and translocation of heavy metals in water hyacinth: Maximising the use of green resources to remediate sites impacted by e-waste recycling activities. Ecological Indicators, 115: 106384.

[11] El-Chaghaby, G. A., Moneem, M. A., Rashad, S. & Murthy, C. (2022). A review on potential uses of invasive aquatic weed; water hyacinth. Egyptian Journal of Aquatic Biology & Fisheries, Ain Shams University, Cairo, Egypt. Vol. 26(1): 457 – 467.

[12] El-Din, S.B. & Aziz, R.A.A. (2018). Potential uses of aquatic plants for wastewater treatment. J Microbiol Biotechnol. Rep., 2: 47-48.

[13] Haryanto, A., S. Triyono, & P. M. Siska. (2020). Use of water hyacinth (Eichhornia crassipes) to treat biogas effluent of a tapioca industry wastewater treatment system. Agricultural Engineering International: CIGR Journal, 22 (4):9-19.

[14] Juárez-Luna, G. N.; Favela-Torres, E.; Quevedo, I. R. & Batina, N. (2019). Enzymatically assisted isolation of high-quality cellulose nanoparticles from water hyacinth stems. Carbohydrate Polymers, 220: 110–117.

[15] Kinidi, L. & Salleh, S. (2017). Phytoremediation of nitrogen as green chemistry for wastewater treatment system. Int. J. Chem. Eng., 12: 205. https://doi.org/10.1155/2017/1961205

[16] Koupai, J.A., Jamalian, M. A. & Dorafshan, M. M. (2019). Improving Isfahan landfill leachate quality by phytoremediation using Vetiver and Phragmites plants for using in green space irrigation. J. Water Wastewater, 16: 2867. Doi:10.22093/wwj.2019.186145.2867

[17] Kumar, P. and Chauhan, M. S. (2019). Adsorption of chromium (VI) from the synthetic aqueous solution using chemically modified dried water hyacinth roots. Journal of Environmental Chemical Engineering, 7(4): 103218.

[18] Magar, R., Khan, A. & Honnutagi, A. (2017). Wastewater treatment using water hyacinth. Int. Eng. Cong., 32: 546.

[19] Ndimele, P. (2012). The effects of water hyacinth, Eichhornia crassipes (Mart. Solms) Infestation on the physico-chemistry, nutrient and heavy metal content of Badagry Creek and Ologe Lagoon, Lagos, Nigeria. Journal of Environmental Science and Technology, 5(2), 128–136. doi:10.3923/jest.2012.128.136

[20] Ogunbodede Bolawole F., Anthony C. O Iweka & Akinfolarin Jobi (2022). Human Waste Management, Storage and Disposal in Nigeria: Implications to Residential Apartments in Ikeja, Lagos. Kufa Journal of Engineering Vol. 13, No. 3, P.P. 59-72.

[21] Reddy, K. R., Agami, M., & Tucker, J. C. (2015). Management of aquatic plant species for biomass production. Journal of Aquatic Plant Management, 53, 107-120.

[22] Rezania, S.; Ponraj, M.; Fadhil Md Din, M.; Chelliapan, S. & Md Sairan, F. (2016). Effectiveness of Eichhornia crassipes in nutrient removal from domestic wastewater based on its optimal growth rate. Desalination and Water Treatment, 57(1): 360–365.

[23] Siswoyo, E., Utari, A. W. & Mungkari, L. G. (2019). Adsorption combined phytoremediation system for treatment of laundry wastewater. MATEC Web Conf., 280: 05002 https://doi.org/10.1051/matecconf /20192800 5002system. Int. J. Phytoremed.system. Int. J. Phytoremed.

[24] Tamara Avellán, Paul Gremillion (2019). Constructed wetlands for resource recovery in developing countries, Renewable and Sustainable Energy Reviews,Volume 99, 2019, Pages 42-57, ISSN 1364-0321,

[25] Wang, Z.; Zhang, Z.; Zhang, J.; Zhang, Y.; Liu, H. & Yan, S. (2012). Large-scale utilization of water hyacinth for nutrient removal in Lake Dianchi in China: The effects on the water quality, macrozoobenthos and zooplankton. Chemosphere, 89(10): 1255–1261.

[26] Wickramasinghe, S. & Jayawardana, C. K. (2018). The potential of aquatic macrophytes Eichhornia crassipes, Pistia stratiotes, and Salvinia molesta in phytoremediation of textile wastewater.

[27] Wimalarathne, H. D. A. & Perera, P. C. D. (2019). Potentials of water hyacinth as livestock feed in Sri Lanka. Indian Journal of Weed Science, 51(2): 101.

[28] Zhang, C.; Ma, X.; Chen, X.; Tian, Y.; Zhou, Y.; Lu, X. and Huang, T. (2020). Conversion of water hyacinth to value-added fuel via hydrothermal carbonization. Energy, 197: 117193.

[29] Zhou, R.; Zhang, M.; Li, J. and Zhao, W. (2020). Optimization of preparation conditions for biochar derived from water hyacinth by using responsurface methodology (RSM) and its application in Pb2+ removal. Journal of Environmental Chemical Engineering, 8(5): 104198.