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EFFECT OF BREWERY EFFLUENT ON MORPHOLOGICAL CHARACTERISTICS AND PHYSIOLOGICAL TRAITS OF *Ipomoea aquatica* Forsk. (FAMILY: CONVOLVULACEAE)

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Abstract

This study investigated the effects of brewery effluent on the growth and morphology of *Ipomoea aquatica* Forsk. under controlled screen house conditions at the University of Benin Screen House, Nigeria, in 2021. The experiment lasted fifteen days and aimed to evaluate how varying concentrations of effluent influence plant development. Effluent samples were diluted to obtain different concentrations viz. 10%, 25%, 50%, and 75%, while the undiluted sample and river water served as (100%) treatments and control (0%) respectively. Physico-chemical properties of the effluent such as pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), and heavy metal contents were analyzed. Plant parameters including chlorophyll content index (CCI), leaf number, root number, and plant height were measured at intervals of three days (Days 0, 3, 6, 9, 12, and 15). Potentiometric determination of effluent's pH showed that it was slightly acidic (5.4), with EC and TDS values of 1878 µS/cm and 941 mg/L, respectively. Iron (0.26 mg/L) and zinc (0.02 mg/L) were detected in the 100% effluent, while Chromium, Copper, Nickel and Lead were absent. Growth responses varied significantly across treatments. At lower concentrations (10% and 25%), *I. aquatica* exhibited enhanced chlorophyll content and increase in leaf number, indicating growth stimulation possibly due to nutrient availability in the diluted effluent. In contrast, higher concentrations (50% – 100%) caused progressive growth inhibition and eventual plant death by Day 15. Notably, CCI at 10% effluent (36.63 ± 9.66) was significantly higher than at 75% and 100%, which recorded zero values due to complete mortality ($p < 0.05$). The findings reveal that while mildly diluted brewery effluent promoted plant growth, while higher concentrations have toxic effects leading to total mortality. This demonstrates the importance of effluent dilution or treatment before discharge into the environment or its use for irrigation of farmland. Moreover, *I. aquatica* can serve as a reliable bioindicator for assessing the ecological impact of industrial effluents on aquatic systems.

Keywords: Bioindicator, brewery effluent, chlorophyll content, *Ipomoea aquatica*, pollution monitoring

INTRODUCTION

Industrial growth and rapid urbanization in Nigeria have resulted in the continuous discharge of untreated or inadequately treated industrial effluents into the environment, leading to widespread pollution, deterioration of water and soil quality, ecological degradation, and increased risks to human health (Darma *et al.*, 2024; Martins and Mafimisebi, 2024). Industrial wastewater is frequently discharged into the environment in Nigeria with little or no treatment, resulting in severe environmental pollution, aquatic ecosystems degradation, and significant public health concerns (Martins and Mafimisebi, 2024). Untreated brewery effluents are rich in organic and inorganic pollutants that increase biological oxygen demand (BOD), chemical oxygen demand (COD), turbidity, and nutrient concentrations, thereby altering the physicochemical characteristics of receiving waters and posing risks to aquatic ecosystems (Alemu *et al.*, 2022). Khan *et al.* (2023) reported that brewery wastewater typically contains high concentrations of biodegradable organic matter (high BOD and COD), suspended solids, nutrients, and dissolved inorganic constituents. When discharged without adequate treatment, these pollutants degrade water quality by altering physicochemical properties, reducing dissolved oxygen, and negatively affecting aquatic organisms.

Aquatic pollution results from the introduction of harmful physical, chemical, or biological contaminants into water bodies, leading to deterioration of water quality, disruption of aquatic ecosystems, and increased risks to human and environmental health (World Health Organization and UN-Habitat, 2024). Ikpoba River in Benin City, Edo State, is one of such affected water bodies. It receives industrial discharges from Guinness Nigeria Brewery, the University of Benin Teaching Hospital, and nearby abattoirs, leading to increased contamination and reduced suitability for domestic or agricultural use (Igbinosa *et al.,* 2021). Brewery effluent are known to elevate biological and chemical oxygen demand, lower dissolved oxygen, and sometimes introduce toxic metals, thereby disturbing aquatic ecosystems (Olorunfemi *et al.,* 2024, UNEP and WHO, 1996). Aquatic macrophytes play vital ecological roles in freshwater ecosystems by contributing to nutrient cycling, habitat provision, primary productivity, and water purification. Because they respond sensitively to changes in water chemistry and accumulate pollutants in their tissues, their growth, physiology, and morphology are widely used as reliable bioindicators of water quality and aquatic pollution (Polechońska and Klink, 2023; Gecheva *et al.*, 2023). *Ipomoea aquatica* Forsk. -Water Spinach; also known as Swamp Morning-Glory is a hairless, aquatic perennial with milky latex and a hollow, creeping stem that roots at the nodes, trails on mud or floats on water, reproduces from vegetative stem and stolons and rarely from seeds (Akobundu *et al.*, 2016). It is a fast-growing aquatic macrophyte that thrives in nutrient-rich water and

responds visibly to pollutants, making it suitable for assessing effluent toxicity (Kovoor *et al.*, 2012).
This study, conducted in 2021 at the Screen House of the Department of Plant Biology and Biotechnology, University of Benin, Benin City, Edo State was carried out to evaluated the effects of brewery effluent on the growth, morphology and physiology of *I. aquatica* and to explore its potential as a bioindicator of pollution in aquatic environment.

MATERIALS AND METHODS

Study Site and Collection of Samples

Brewery effluent was collected from the Guinness Nigeria Brewery discharge point at Ikpoba Hill, Benin City, and diluted with Ikpoba River water to prepare different concentrations. Sampling followed American Public Health Association (2023) standards, and the experiment was carried out in the screen house of the Department of Plant Biology and Biotechnology, University of Benin.

Collection of Aquatic Macrophytes

Fresh *Ipomoea aquatica* plants were collected from Ikpoba River in April 2021, placed in bucket of water and identified by lead author and confirmed using standard taxonomic literature (Akobundu *et al.,* 2016) Voucher specimen was deposited at the University of Benin Herbarium with Voucher number UBH-I551. The stem cutting was acclimatized for two days in the screen house in 1 Litre of river water in each bowl before the experiment was set up on the 3rd day.

Physico-Chemical Analysis of Effluent

The physico-chemical properties of the effluent and river water (control) were analyzed using standard procedures (American Public Health Association, 2023) to determine parameters such as pH, Electrical Conductivity, Total Dissolved Solid, major ions, and heavy metals.

pH Measurement

The hydrogen ion concentration of the effluent was measured using a calibrated digital pH meter. The instrument was standardized with buffer solutions before use (Andersen and Menong, 2025; Shehata *et al.,* 2023).

Temperature

Temperature was recorded *in situ* using a digital 4-in-1 digital meter.

Electrical Conductivity

Electrical conductivity was determined using a digital conductivity meter (American Public Health Association, 2023).

Total Suspended Solids (TSS)

Fifty millilitres of the sample was filtered through a pre-weighed filter paper. The filter paper was then oven-dried at 100 °C and reweighed. TSS (mg/L) was calculated using:

$$\text{TSS} = \frac{\text{Final Weight} - \text{Initial Weight} \times 1000}{Sample\ Volume}$$

Total Dissolved Solids (TDS)

TDS was measured using a digital 4-in-1 TDS/EC/pH and Temperature meter (Hanna Instruments HI 9032). The electrode was rinsed and immersed in the sample, and readings were expressed in mg/L.

Total Solids (TS)

Total solids were determined gravimetrically. A clean, dried beaker was weighed (B), filled with 50 mL of the sample, evaporated to dryness, cooled, and reweighed (A):

$$\text{TS (mg/L)} = \frac{(\text{A}-\text{B}) \times 1000}{Volume\ of\ Sample}$$

Turbidity

Turbidity was measured in nephelometric turbidity units (NTU) using an electronic turbidimeter calibrated with distilled water.

Heavy Metals Determination

Concentrations of heavy metals (Fe, Zn, Cu, Cr, Cd, Ni and Pb) were determined using Atomic Absorption Spectrophotometry (AAS). Each metal was analyzed with its corresponding hollow cathode lamp. Sample absorbance was measured according to the Beer-Lambert law, with results expressed in mg/L.

Chlorophyll Measurement

Chlorophyll was determined using a handheld digital Chlorophyll Content Meter (CCM-200 Plus) (Apogee instrument, USA). Plant height was measured using a ruler, Leaf and root numbers were counted physically with the naked eyes. Plant biomass was measured using sensitive weighing balance

Data Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics (mean ± standard error) were calculated for all parameters. One-way Analysis of Variance (ANOVA) was applied to test for significant differences among treatments, followed by Duncan's Multiple Range Test (DMRT) at a 5 % significance level ($P < 0.05$).

RESULTS

The physico-chemical analysis showed that the brewery effluent was slightly acidic (pH 5.4) with high electrical conductivity (1878 µS/cm) and total dissolved solids (941 mg/L), indicating a high ionic content. Turbidity was considerable (133 NTU), and total hardness measured 75.2 mg/L. Only trace amounts of iron (0.26 mg/L) and zinc (0.02 mg/L) were detected, while chromium, copper, lead, and nickel were absent (Table 1).

Table 1: Physico-Chemical Parameters of Brewery Effluent

Parameters	Quantity
pH	5.4
Colour	102.0 pt Co
Turbidity	133.0 NTU
E.C	1878 µs/cm
TDS	941.0 mg/L
TSS	58.0 mg/L
Alkalinity	57.5 mg/L
Total Hardness	75.2 mg/L
Calcium	20.45 mg/L
Magnesium	5.86 mg/L
Sulphate	21 mg/L
Nitrate	0.21 mg/L
Phosphate	0.34 mg/L
Cadmium	0
Iron	0.26 mg/L
Chromium	0
Lead	0
Copper	0
Zinc	0.02 mg/L
Nickel	0

Chlorophyll Content Index (CCI)

The chlorophyll content of *I. aquatica* showed a clear response to the different effluent concentrations over the fifteen-day period (Figure 1). At lower concentrations (10 % and 25 %), CCI values increased gradually, reaching 36.63 ± 9.66 at 10 % by day 15. This was higher than the control (27.23 ± 6.09). However, at 75 % and 100 % concentrations, CCI dropped sharply and eventually reached zero as the plants died before the end of the experiment. Differences were significant ($p < 0.05$) between the lower and higher concentrations.

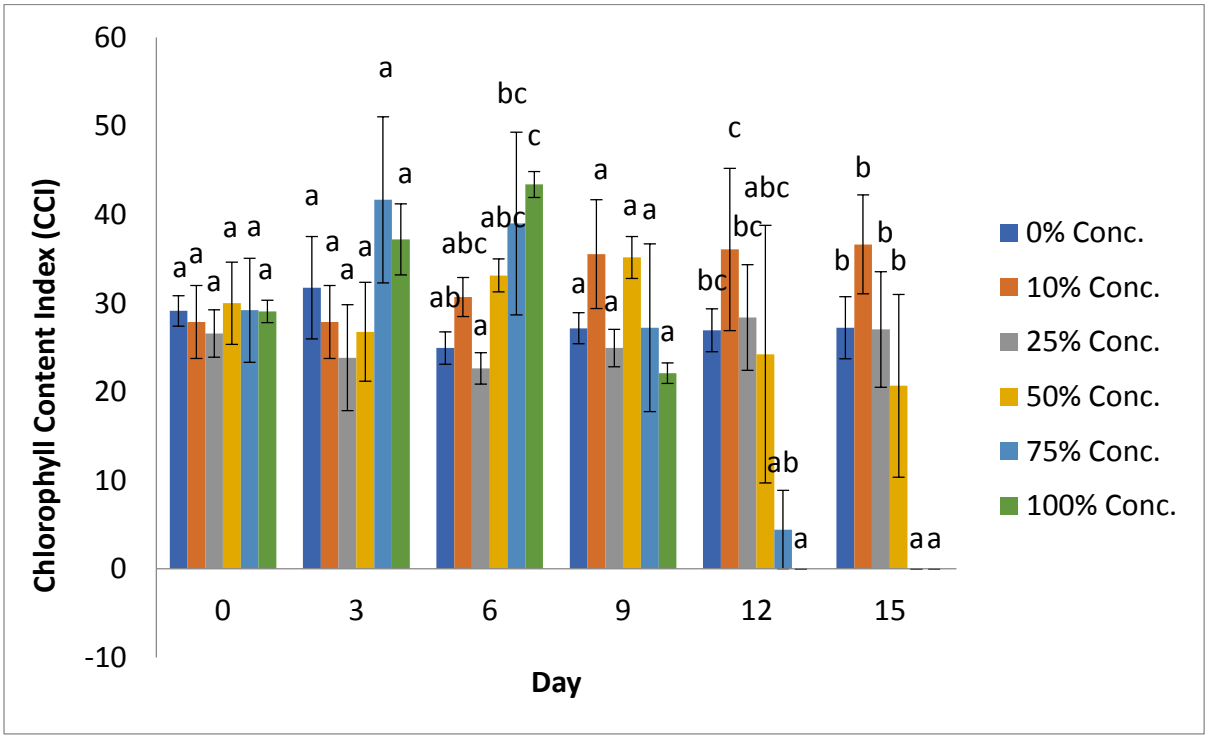

Figure 1: Chlorophyll Content Index of *Ipomoea aquatica* grown in Brewery Effluent

Bars with similar alphabets (on the same day) are not significantly different from each other (P > p0.05)

Other parameters measured -such as leaf and root numbers, plant height, temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), and plant biomass -are presented in Tables 2 to 8. Leaf numbers showed no significant difference (P > 0.05) among treatments up to day 9, except between 25 % treatment and the control (0 %) on day 3 and 6. By days 12 and 15, significant differences (P < 0.05) occurred, especially at 75 % and 100 % effluent concentrations. Plants in these higher treatments experienced severe leaf wilting and defoliation, leading to complete death at 100 % effluent on days 12 and 15. Conversely, the 10 % and 25% treatments recorded a steady increase in leaf number, suggesting that the diluted effluent may have supplied beneficial nutrients. The 75 % and 100 % concentrations caused early leaf loss and stunted growth, confirming the toxic effect of concentrated effluent on *I. aquatica*.

Table 2: Mean Number of Leaves of *Ipomoea aquatica* Treated with Brewery Effluent

Conc. (%)	Day after Set-up of Experiment					
	0	3	6	9	12	15
0	$4.00^{a} \pm 0.00$	$2.67^{a} \pm 0.67$	$2.67^{a} \pm 0.67$	$3.33^{a} \pm 0.33$	$4.67^{ab} \pm 0.33$	$5.33^{b} \pm 0.33$
10	$4.00^{a} \pm 0.00$	$4.00^{ab} \pm 0.00$	$4.67^{ab} \pm 0.33$	$4.67^{a} \pm 0.33$	$6.67^{b} \pm 1.45$	$7.33^{b} \pm 1.45$
25	$4.00^{a} \pm 0.00$	$4.33^{b} \pm 0.33$	$4.33^{b} \pm 0.33$	$5.00^{a} \pm 0.58$	$6.00^{ab} \pm 0.00$	$6.33^{b} \pm 0.33$
50	$4.00^{a} \pm 0.00$	$4.00^{ab} \pm 0.00$	$4.33^{ab} \pm 0.33$	$4.00^{a} \pm 0.58$	$4.33^{ab} \pm 0.67$	$4.67^{b} \pm 0.88$
75	$4.00^{a} \pm 0.00$	$4.00^{ab} \pm 0.00$	$3.33^{ab} \pm 0.33$	$3.17^{a} \pm 0.33$	$3.00^{ab} \pm 0.58$	$0.00^{a} \pm 0.00$
100	$4.00^{a} \pm 0.00$	$4.00^{ab} \pm 0.00$	$3.33^{ab} \pm 0.33$	$3.00^{a} \pm 0.58$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$

Means down a column with different superscripts alphabets are significantly different from each other ($P \leq 0.05$).

Table 3: Mean Numbers of Root of *Ipomoea aquatica* in Treated Brewery Effluent

Conc. (%)	Day after Set-up of Experiment					
	0	3	6	9	12	15
0	0	$7.67^{c} \pm 3.79$	$19.67^{c} \pm 0.58$	$21.33^{c} \pm 1.53$	$21.33^{c} \pm 1.53$	$23.33^{c} \pm 1.15$
10	0	$5.67^{bc} \pm 3.79$	$9.33^{b} \pm 1.15$	$8.67^{b} \pm 0.58$	$8.67^{b} \pm 0.58$	$8.67^{b} \pm 0.58$
25	0	$1.67^{ab} \pm 2.89$	$3.00^{a} \pm 2.65$	$3.00^{a} \pm 2.56$	$3.33^{a} \pm 2.89$	$3.33^{a} \pm 2.89$
50	0	$0.00^{a} \pm 0.00$	$0.33^{a} \pm 0.58$	$0.33^{a} \pm 0.58$	$1.33^{a} \pm 2.31$	$1.33^{a} \pm 2.31$
75	0	$0.00^{a} \pm 0.00$	$1.33^{a} \pm 2.31$	$1.33^{a} \pm 2.31$	$1.33^{a} \pm 2.31$	$1.33^{a} \pm 2.31$
100	0	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.0$	$0.00^{a} \pm 0.00$

Means down a column with different superscripts alphabets are significantly different from each other ($P \leq 0.05$).

Table 4: Mean Plant Height of *Ipomoea aquatica* in Treated Brewery Effluent

Conc. %	Day after Set-up of Experiment					
	0	3	6	9	12	15
0	$28.67^{a} \pm 0.29$	$29.00^{a} \pm 0.87$	$29.03^{a} \pm 0.92$	$36.83^{b} \pm 4.01$	$37.00^{b} \pm 3.98$	$39.97^{b} \pm 0.49$
10	$28.67^{a} \pm 0.29$	$28.67^{a} \pm 0.29$	$28.67^{a} \pm 0.29$	$28.67^{a} \pm 0.29$	$28.67^{a} \pm 0.29$	$28.83^{a} \pm 0.29$
25	$26.67^{a} \pm 3.21$	$26.70^{a} \pm 3.25$	$26.77^{a} \pm 3.33$	$26.77^{a} \pm 3.33$	$26.77^{a} \pm 3.33$	$26.77^{a} \pm 3.33$
50	$27.17^{a} \pm 1.89$	$27.17^{a} \pm 1.89$	$27.17^{a} \pm 1.89$	$27.17^{a} \pm 1.89$	$27.17^{a} \pm 1.89$	$27.17^{a} \pm 1.89$
75	$28.50^{a} \pm 0.50$	$28.57^{a} \pm 0.51$	$28.60^{a} \pm 0.53$	$28.60^{a} \pm 0.53$	$28.60^{a} \pm 0.53$	$28.60^{a} \pm 0.53$
100	$29.50^{a} \pm 0.50$	$29.57^{a} \pm 0.55$	$29.57^{a} \pm 0.55$	$29.57^{a} \pm 0.55$	$29.53^{a} \pm 0.50$	$29.53^{a} \pm 0.50$

Means down a column with different superscripts alphabets are significantly different from each other ($P \leq 0.05$).

Table 5: Temperature (ºC) in Experimental Brewery Effluent during the Period of Experiment

Concentration (%)	Day after Set-up of Experiment			
	0	3	6	12
0	$14.4^{a} \pm 1.20$	$13.6333^{b} \pm 0.06$	$14.2333^{d} \pm 0.55$	$13.4667^{c} \pm 0.23$
10	$14.4^{a} \pm 0.95$	$12.5667^{a} \pm 0.06$	$14.0333^{cd} \pm 0.21$	$13.9333^{c} \pm 0.12$
25	$15.0667^{a} \pm 0.06$	$13.1667^{b} \pm 0.55$	$13.7667^{bc} \pm 0.06$	$12.4667^{a} \pm 0.64$
50	$13.8333^{a} \pm 0.68$	$12.5667^{a} \pm 0.06$	$13.5^{ab} \pm 0.10$	$12.5667^{a} \pm 0.06$
75	$15.2^{a} \pm 2.60$	$13.1333^{ab} \pm 0.65$	$13.3^{a} \pm 0.10$	$13.2^{c} \pm 0.10$
100	$13.93^{a} \pm 0.93$	$12.5^{a} \pm 0.26$	$13.13^{a} \pm 0.06$	$13.07^{b} \pm 0.06$

Means down the same column with different superscripts alphabets are significantly different from each other ($P < 0.05$)

Table 6: pH in Experimental Brewery Effluent During the Period of Experiment

Concentration (%)	Day after Set-up of Experiment				
	0	3	6	12	15
0	$4.20^{d} \pm 0.00$	$5.60^{a} \pm 0.26$	$5.47^{de} \pm 0.49$	$4.50^{b} \pm 0.61$	$6.73^{bc} \pm 0.15$
10	$3.87^{c} \pm 0.06$	$4.57^{c} \pm 0.12$	$4.63^{bc} \pm 0.25$	$4.33^{b} \pm 0.21$	$6.97^{bc} \pm 0.92$
25	$3.80^{bc} \pm 0.00$	$5.63^{c} \pm 0.06$	$5.67^{e} \pm 0.06$	$5.70^{c} \pm 0.10$	$6.20^{ab} \pm 0.40$
50	$3.77^{bc} \pm 0.06$	$4.07^{b} \pm 0.12$	$5.07^{cd} \pm 0.06$	$5.57^{c} \pm 0.90$	$7.60^{c} \pm 0.30$
75	$3.73^{b} \pm 0.06$	$4.10^{a} \pm 0.10$	$4.23^{ab} \pm 0.25$	$3.27^{a} \pm 0.29$	$5.80^{a} \pm 0.56$
100	$3.60^{a} \pm 0.10$	$4.00^{a} \pm 0.10$	$4.13^{a} \pm 0.06$	$4.07^{ab} \pm 0.25$	$5.70^{a} \pm 0.17$

Means down the same column with different superscripts alphabets are significantly different from each other ($P < 0.05$)

Table 7: Electrical Conductivity (µS/cm) in Experimental brewery Effluent

Concentration (%)	Day after Set-up of Experiment			
	0	3	6	12
0	$147.00^{b} \pm 11.27$	$80.33^{a} \pm 54.00$	$111.00^{a} \pm 3.61$	$111.33^{a} \pm 3.06$
10	$17.60^{a} \pm 0.26$	$180.00^{b} \pm 53.69$	$210.67^{b} \pm 11.93$	$183.33^{b} \pm 55.18$
25	$234.00^{c} \pm 12.17$	$302.33^{c} \pm 3.21$	$253.00^{c} \pm 14.11$	$238.33^{c} \pm 32.08$
50	$274.67^{c} \pm 48.84$	$421.00^{d} \pm 8.89$	$348.67^{d} \pm 11.02$	$331.00^{d} \pm 24.06$
75	$250.00^{c} \pm 20.00$	$472.00^{d} \pm 26.46$	$438.00^{e} \pm 9.17$	$438.00^{e} \pm 7.94$
100	$463.33^{d} \pm 89.63$	$539.33^{e} \pm 44.06$	$517.00^{f} \pm 7.81$	$513.00^{f} \pm 8.19$

Mean values of three replicates ± standard error of mean with different superscripts alphabets are significantly different from each other ($P < 0.05$)

Table 8: Total Dissolved Solids (TDS) (mg/L) in Experimental Brewery Effluent

Concentration (%)	Day after Set-up of Experiment			
	0	3	6	12
0	$74.00^{a} \pm 6.25$	$61.67^{b} \pm 5.77$	$163.00^{bc} \pm 2.65$	$163.67^{a} \pm 2.08$
10	$81.00^{b} \pm 10.39$	$86.00^{c} \pm 5.20$	$160.33^{bc} \pm 42.91$	$169.67^{a} \pm 45.39$
25	$116.00^{b} \pm 6.08$	$130.67^{d} \pm 1.16$	$151.00^{b} \pm 9.54$	$150.00^{a} \pm 10.39$
50	$142.33^{b} \pm 33.83$	$185.00^{e} \pm 4.36$	$191.00^{c} \pm 1.00$	$146.67^{a} \pm 37.86$
75	$126.67^{b} \pm 5.51$	$123.03^{a} \pm 0.91$	$223.27^{a} \pm 0.21$	$227.67^{b} \pm 5.86$
100	$280.33^{c} \pm 23.70$	$300.67^{f} \pm 3.51$	$278.67^{d} \pm 2.08$	$276.33^{c} \pm 4.73$

Means down the same column with different superscripts alphabets are significantly different from each other ($P < 0.05$)

Table 9: *Ipomoea batatas* Plant Biomass Parameters (g)

Conc. %	Fresh Root	Fresh Shoot	Shoot and Root	Dry Root	Dry Shoot	Dry Shoot and Root
0	0.201	6.354	6.555	0.106	2.223	2.329
10	0.037	6.373	6.410	0.036	3.069	3.093
25	0.082	10.394	10.476	0.039	4.310	4.349
50	0.022	4.227	4.249	0.067	1.792	1.859
75	0.013	1.860	1.873	0.010	0.719	0.729
100	0.000	2.436	2.436	0.240	0.747	0.987

DISCUSSION

The findings of this study clearly demonstrate that brewery effluent significantly affects the growth, morphology, and physiological performance of *Ipomoea aquatica*. The variations observed among treatments indicate a dual effect of the effluent, whereby diluted concentrations provide nutrient enrichment that stimulates plant growth, whereas higher concentrations induce toxicity and physiological stress. The slightly acidic pH (5.4), together with elevated electrical conductivity (EC) and total dissolved solids (TDS), indicates that the brewery effluent contained substantial amounts of dissolved salts and organic matter, characteristics that are consistently reported for brewery wastewater (Adekunle *et al.*, 2023; Olatunji *et al.*, 2022). High EC and TDS increase osmotic pressure around plant roots, thereby reducing water uptake, disrupting nutrient absorption, and ultimately impairing plant growth (FAO, 2023). At 10 % and 25 % effluent concentrations, the increase in chlorophyll content and improved leaf development observed in *I. aquatica* suggests that the diluted effluent supplied nutrients, particularly nitrogen and phosphorus, which enhanced photosynthetic activity and vegetative growth. Similar stimulatory responses at low concentrations of industrial wastewater have been reported by Kandasamy *et al.* (2025), who observed that nutrient-rich diluted brewery wastewater enhanced early plant growth before toxic effects became apparent at higher concentrations. Likewise, Adeleke *et al.* (2023) reported that controlled application of nutrient-containing agro-industrial wastewater may improve plant productivity when pollutant levels remain below phytotoxic thresholds. Conversely, growth inhibition, chlorosis, and reduced root and leaf development at 50 % – 100 % effluent concentrations indicate toxic effects associated with excessive organic loading, salinity, and metal accumulation. High concentrations of brewery wastewater are known to reduce chlorophyll synthesis, inhibit photosynthesis, interfere with antioxidant enzyme activities, and induce oxidative stress in plants (Kandasamy *et al.*, 2025; Salian *et al.*, 2018). Although iron (0.26 mg/L) and zinc (0.02 mg/L) concentrations recorded in this study were relatively low, prolonged exposure may still result in bioaccumulation, membrane damage, and metabolic disturbances, particularly when combined with elevated EC and acidic conditions (Adeleke *et al.*, 2023). Comparable phytotoxic responses have been documented in maize exposed to untreated brewery effluent. Salian *et al.* (2018) and Kandasamy *et al.* (2025) reported significant reductions in seed germination, shoot elongation, root growth, and seedling vigour due to elevated organic load, increased salinity, and the presence of toxic constituents. These observations agree with the present findings and further support earlier reports by Atuanya *et al.* (2012) who demonstrated reduced germination, chlorophyll degradation, and biomass loss following exposure to untreated brewery wastewater. The decline in leaf number and root development observed at 75 % and 100 % effluent concentrations in the present study therefore confirms the concentration-dependent phytotoxicity of brewery effluent. The results further indicate that *I. aquatica* possesses moderate tolerance to diluted brewery effluent but becomes increasingly susceptible to undiluted wastewater. This response reflects the adaptive characteristics of the species as a semi-aquatic macrophyte capable of thriving in nutrient-rich environments while remaining vulnerable to excessive ionic strength, acidity, and pollutant accumulation. The relatively constant temperature recorded throughout the experiment suggests that the observed growth responses were primarily influenced by changes in pH, EC, and TDS rather than environmental temperature. Acidic conditions reduce nutrient availability, impair chlorophyll biosynthesis, and suppress enzyme activity, thereby contributing to reduced photosynthetic efficiency and growth inhibition (FAO, 2023; Adekunle *et al.*, 2023). The progressive increase in EC and TDS with increasing effluent concentration further confirms the accumulation of dissolved ions within the experimental media. Elevated ionic concentrations create osmotic stress that limits root elongation, decreases leaf expansion, and reduces overall biomass accumulation, effects that were evident in the present study. Similar relationships between elevated EC, TDS, and reduced plant performance have been reported in recent investigations of industrial wastewater irrigation (Olatunji *et al.*, 2022; Adeleke *et al.*, 2023). The initial stimulation followed by progressive inhibition observed across treatments therefore illustrates the balance between nutrient availability and pollutant toxicity. Overall, the responses of *Ipomoea aquatica* demonstrate its suitability as a sensitive bioindicator of brewery effluent pollution. The rapid appearance of chlorosis, wilting, reduced chlorophyll content, stunted growth, and mortality at higher effluent concentrations indicates that the species responds predictably to increasing pollutant levels. Such characteristics make *I. aquatica* valuable for ecological monitoring, phytotoxicity assessment,

and environmental risk evaluation of industrial wastewater discharged into freshwater ecosystems.

CONCLUSION AND RECOMMENDATION

This study demonstrated that brewery effluent significantly affects the growth, morphology and physiology of *Ipomoea aquatica* Forsk., with lower concentrations (10 % – 25 %) enhancing growth and higher concentrations (50 % – 100 %) causing toxicity and eventual plant death. The slightly acidic nature and high dissolved solid content of the effluent indicate the presence of both nutrients and harmful substances. While mild dilution can provide some nutritive benefits, undiluted effluent poses serious ecological risks to aquatic environments. It is therefore essential that brewery wastewater be properly treated before disposal to prevent contamination of water bodies. Regulatory agencies should strengthen monitoring efforts and enforce compliance with effluent standards, while industries are encouraged to adopt environmentally sustainable practices. The use of *I. aquatica* as a bioindicator is recommended for regular monitoring of effluent-impacted waters, and further research should examine the long-term ecological effects of such discharges on aquatic ecosystems.

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