Sahel Journal of Life Sciences FUDMA (SAJOLS)
September 2025 Vol. 3(3): 240-250
ISSN: 3027-0456 (Print)
ISSN: 1595-5915 (Online)
DOI: https://doi.org/10.33003/sajols-2025-0303-30

Research Article

Potential of Microalgae Cultivated in Wastewater for Enhancing Biodiesel Production

***Muhammad, B.[1], Bukar, A.[2], Shamsudeen, U.[2], Habibu, U. A.[2], and Ali, M.[3]**

[1]Department of Applied Biology, Faculty of Life Sciences, Federal University of Sciences and Technology, Babura, Jigawa, Nigeria
[2]Department of Microbiology, Faculty of Life Sciences, Bayero University, Kano, Nigeria
[3]National Population Commission, Federal Secretariat Dutse, Jigawa State, Nigeria
****Corresponding Author's email*: mbello.bio@futb.edu.ng; Phone: +2348067697541**

ABSTRACT

The rising global demand for sustainable and environmentally friendly energy sources has intensified interest in biofuels, particularly biodiesel. Among the various feedstock's explored for biodiesel production, microalgae have emerged as a promising alternative due to their high lipid productivity, rapid growth rates, and ability to thrive in diverse environments, including wastewater. This study explored the potential of native microalgal strains isolated from wastewater in Sokoto metropolis for biodiesel applications. Physicochemical analysis of the wastewater revealed temperature (25.3 ± 0.5 °C), biochemical oxygen demand (3.4 mg/L), electrical conductivity (3420 µS/cm), dissolved oxygen (39.51 mg/L), nitrate (0.29 mg/L), phosphate (28.65 mg/L), pH (6.27), and trace metals (Fe, Zn, Pb, Cd, Cr), all of which were within World Health Organization (WHO) permissible limits. Ten isolates were recovered through serial dilution and identified using morphological characteristics. Biomass and lipid productivity were evaluated under a 16:8 h light–dark cycle, and lipid content was quantified gravimetrically. Among the isolates, *Scenedesmus sp*. produced the highest biomass yield (0.224 g/L) and lipid productivity (0.57 ± 0.006 g/L/day). Statistical analysis (ANOVA) showed significant variation ($p < 0.05$) among isolates. The findings indicate that wastewater can serve as a low-cost medium for microalgal cultivation, simultaneously reducing nutrient discharge and treatment costs. Utilizing indigenous microalgae such as *Scenedesmus sp*. offers a promising strategy for sustainable biodiesel production in resource-limited settings.

Keywords: Biodiesel; Biomass; Lipid productivity; Microalgae; Wastewater

Citation: Muhammad, B., Bukar, A., Shamsudeen, U., Habibu, U. A., and Ali, M. (2025). Potential of Microalgae Cultivated in Wastewater for Enhancing Biodiesel Production. *Sahel Journal of Life Sciences FUDMA*, 3(3): 240-250. DOI: https://doi.org/10.33003/sajols-2025-0303-30

INTRODUCTION

The rising global demand for sustainable and environmentally friendly energy sources has intensified interest in biofuels, particularly biodiesel. Among the various feedstock's explored for biodiesel production, microalgae have emerged as a promising alternative due to their high lipid productivity, rapid growth rates, and ability to thrive in diverse environments, including wastewater (Christi, 2007; Mata *et al*., 2010). Unlike traditional oilseed crops, microalgae do not compete with food resources or arable land, making them an attractive candidate for large-scale biofuel production (Mata *et al*., 2010).

Wastewater provides an ideal medium for cultivating microalgae, offering a cost-effective source of nutrients such as nitrogen and phosphorus while simultaneously contributing to bioremediation (Rawat *et al*., 2011). Moreover, using microalgae for biodiesel production in wastewater not only reduces cultivation costs but also addresses environmental issues related to nutrient-rich effluents and heavy metal pollution (Abdel-Raouf *et al*., 2012). Therefore, selecting robust microalgal strains that can survive and perform efficiently in wastewater is critical for optimizing biodiesel yield and environmental benefits. The study aims to explore the

dual potential of wastewater as a medium for microalgal cultivation and microalgae as a sustainable biodiesel feedstock. Specifically, the objectives are: to carry out physicochemical characterization and heavy metal analysis of selected wastewater samples, and isolate and screen indigenous microalgae species based on their biomass productivity, and lipid content, and productivity. The outcomes are expected to identify promising microalgae strains suitable for biodiesel production under wastewater conditions.

MATERIALS AND METHODS

Field sampling

Wastewater were collected from the sampling sites, for the isolation of microalgae, in sterilized 1L sampling bottles at ten different sites within sokoto metropolis, which include Kwalkwalara, Buzaye, K/Ddundaye Haken Idi, Sokoto State University, Kofar kware, Halele, Illela Garage, Mamarun Nupewa and D/Dare. Sampling was conducted at midday, coinciding with the period of maximum photosynthetic efficiency (Emmanuel *et al.,* 2021).

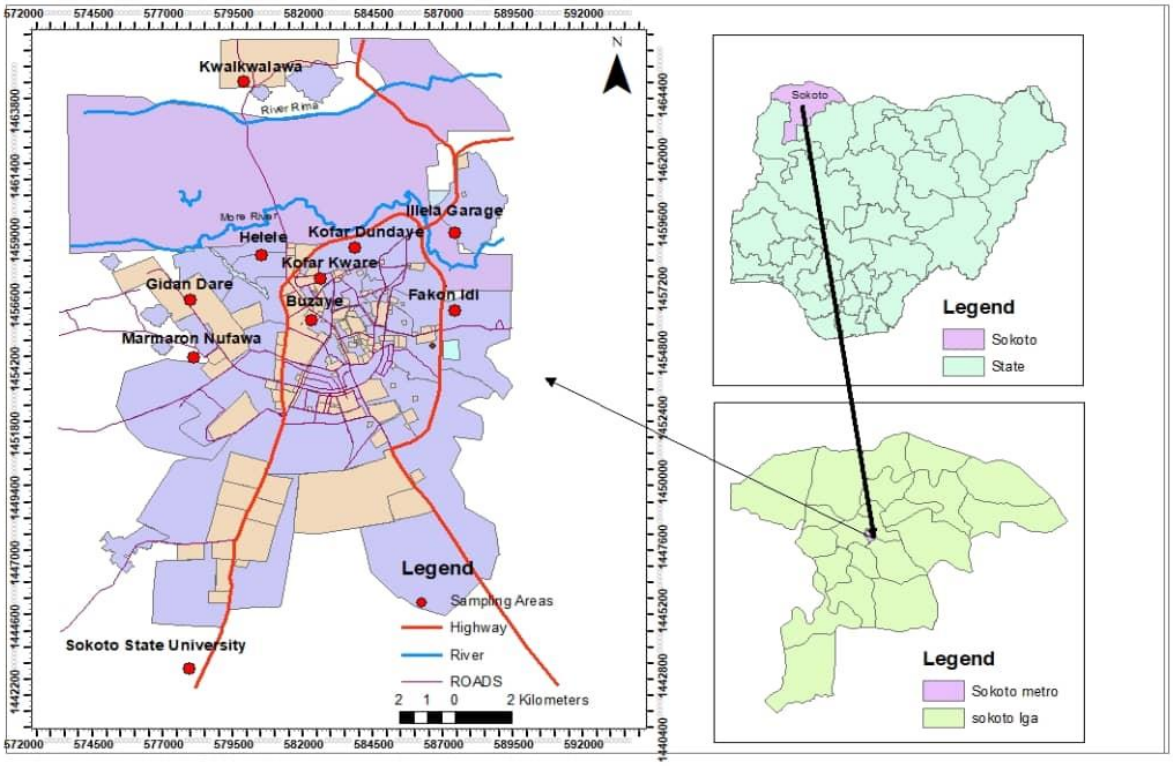

Fig 1. A Map of Sokoto metropolis showing the sampling sites. (Source: Cartographic Unit, Sokoto State University)

Physico-chemical analysis

On arrival at the departmental laboratory, the pH was determined using dip-in mobile battery-operated pH meter, and electrical conductivity of the water samples was determined using EC/TDS bench meter; model (Hach-CO150) as described by APHA (1998). Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined using Wrinkle's titrametric method. The electrical conductivity (EC) was determined using EC/TDS bench meter; model (Hach-CO150) as described by APHA (1998). A multifunctional spectrophotometer model (DR/2010) was used to determine the amount of nitrate and phosphate from the water samples**.**

Determination of Heavy Metals of the Wastewater

Metals contents were analysed prior to inoculation of isolated microalgae species. All collected samples were placed inside sampling box containing ice prior to analysis in the Laboratory. Concentrations of three heavy metals (Fe, Cu and Hg,) were determined using AAS VGP 210 Model. The instrument was set up at wave lengths specific to each element to be analysed.

Five millilitres (5ml) of the samples was used one after the other without delay between them. Distilled deionized water was added frequently between each reading. Readings of the absorbance were obtained by observing the steady galvanometer readings in 1-2 minutes. Determination of each sample was carried out

in triplicate to get representative results (Ado*et al*., 2018).

Isolation and Identification of Microalgae

About 250ml of wastewater from each site was transfer to a 500mL conical flask and incubated on a rotary shaker at 27°C and 150 rpm under continuous illumination using white fluorescent light at intensities of 40µmol m^{-2} s^{-1} for two weeks. Every three days, the flasks were examined for algal growth using an optical microscope, with serial dilutions being made in wastewater from flasks showing growth. Subcultures were made by inoculating 50 µL culture solution onto Petri plates containing Bold's Basal Medium (BBM) solidified with 1.5% (w/v) of bacteriological agar. The plates were incubated at 25°C under continuous illumination for two weeks (Prasanthkumar *et al.,* 2020).

Identification of Algal Species Morphological Identification of Algae

The isolated microalgae were microscopically examined using a high magnification microscope (Olympus, model BX 43, Japan). Microphotographs were obtained using a digital camera (Q imaging, Micropublisher 5.0 RTV, USA) equipped on the microscope. The identification of algae was carried out as per the online database (Guiry and Guiry, 2017).

Microalage cultivation

Microalgae cultivation of isolated strains was conducted in an Erlenmeyer flask (250 mL) containing 120 mL of the wastewater as a growth medium and pH was adjusted to 7.5 with 1M NaOH solution. Standardized 10mL of the microalgal culture having 5.6 x 10^4cells/mL were inoculated in all different sets of experimental. The microalgae culture was exposed to white fluorescent lighting (1200lux), CO_2 concentrations of 5%, with the gas flows from CO_2 cylinder through a line to feed microalgae cells inside the photobioreactor at a flow rate of 200 mL.min^{-1} (~0.06 VVM) using the flow meter (Mousavi et al., 2018). A photoperiod of 16:8 h light/dark cycles, temperature at 25 ± 3°C were maintained during microalgae cultivation period. Cultivation was carried out in triplicates. The cultures were incubated under these conditions for 12 days and gently shaken by hand twice a day to facilitate the distribution of cells and nutrients.

Microalgae growth assays

Sub-samples of 5mL were withdrawn at 3 d intervals for the analysis of microalgal growth patterns. Growth patterns of the microalgal species were determined by measuring optical density (OD) using a UV/Visible Spectrophotometer (Cecil Instruments, England) at a wavelength of 680 nm and a light path of 1 cm (Wang *et al*. 2019). The growth rate (GR, per day) was calculated, as suggested by Wang *et al*. (2010), by fitting the OD observed during the log phase of growth to an exponential function:

$$GR = 1N\frac{(N1 - N0)}{t1 - t0}$$

where N 1 and N 0 are the OD680 values at early and late exponential phase, respectively, whilst t1 and t 0 are the corresponding days. The microalgal biomass was harvested with the used of centrifuge (Hermle Z 233 M-2, Germany) and oven (Binder 230V/10A, Germany). Through centrifuging the microalgae suspension and discarding the supernatant and washing it with distilled water for 3 times, a concentrated suspension has been achieved. The harvested biomass was dried in an oven at 60°C for 24 h as recommended by Storms *et al*. (2014).

Lipid Extraction and Quantification

The lipid were extracted and quantified gravimetrically from the dry algal biomass. Exactly 1 g of air- dried algal biomass was placed into a round-bottom flask and soaked in a mixture of 100 mL of chloroform: methanol (2:1 v/v). The mixture was shaking continuously at 150 rpm for 4 hours in a rotary shaker (RRS-06; Roteck, India). After the shaking, the mixture was centrifuge at 4100×g for 5 min and the residual biomass was separate from the extract. Then, the extract was poured into a separating funnel and 40 mL of distilled water was added. The residual biomass and the oil was kept in a rotary evaporator (Heidolph, model Hei-VAP, Germany) for removal of the excess solvent in the same. The solvent-free dried residual biomass was further extracted using a Soxhlet extractor in 75 mL of hexane, which was refluxed under 70 °C (Prasanthkumar*et al.,*2020). The lipid content of each algal strain was expressed as a percentage of DW, respectively. The lipid productivity of each strain was calculated using Eq.

$$Lipid\ producivity(gL^{-1}d^{-1}) = \frac{Biomass\ productivity}{Lipid\ content}X\ 100$$

RESULTS AND DISCUSSION

Physicochemical Parameters and Heavy Metals Concentration

The results of physicochemical and heavy metals from wastewater are presented in Tables 1 and 2.

Table 1. Physiochemical Analysis of the Waste Water from the Study Area

Collection Site	pH	Temp (^{O}C)	EC (Us/cm)	DO (mg/l)	BOD (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)	Phosphate (mg/l)
Kwalkwalawa	7.3	28	701	5.1	2.54	3.00	3.30	3.9
Buzaye	7.5	24.5	811	4.8	2.91	9.10	3.30	3.30
Kofardundaye	7.5	23.6	820	4.5	2.10	5.80	3.10	3.2
Haken idi	6.6	27.4	135	4.3	2.50	3.50	1.00	6.5
Ssu	7.8	30	34	3.9	2.00	5.90	0.90	6.5
Halele	6.8	28	621	4.7	2.07	4.61	3.40	2.3
Marmaru nupawa	6.2	31	124	4.1	2.20	3.60	2.70	5.1
Gidan dare	6.3	30	76	4.9	2.95	5.41	3.20	4.4
Kofarkware	7.7	25.1	151	4.8	2.44	6.80	2.90	2.6
Illela Garage	5.5	31	116	4.7	2.10	4.16	3.00	2.8

Table 2. Heavy Metals Concentration in the Waste Water from the Study Area

Collection site	Chromium (ppm)	Lead (ppm)	Heavy (ppm)	Cadmium	Metals Iron(ppm)	Zn (ppm)	Copper (ppm)
Kwalkwalawa	2.30	0.02	0.12		0.50	3.20	2.12
Buzaye	2.20	0.07	0.05		0.70	4.01	2.30
Kofardundaye	1.13	0.05	0.07		0.40	4.00	1.40
Haken idi	2.10	0.06	0.10		0.15	2.50	1.45
Ssu	0.00	0.00	0.00		0.02	1.21	0.60
Halele	1.25	0.06	0.01		0.30	2.80	1.44
M/nupawa	2.20	0.02	0.11		0.25	1.95	0.96
Gidan dare	2.00	0.04	0.12		0.60	3.30	0.85
Kofarkware	1.95	0.08	0.04		0.71	2.75	1.77
Illela Garage	2.16	0.07	0.17		0.81	4.05	2.40

The pH values across sampling sites range from 6.2-7.8. This range is within the WHO and NESREA recommended limits for effluent discharge (6.0–9.0), indicating that the water is either slightly acidic or neutral. However, pH values toward the lower end (e.g., 6.2–6.4) may affect enzymatic activity in aquatic organisms and reflect organic acid accumulation. According to Omoigberale *et al*. (2020), near-neutral pH is necessary for optimal aquatic biodiversity, while acidic shifts may indicate underlying organic pollution or industrial discharge. The temperature of wastewater varied from 25.1°C -31.0°C. These values are slightly elevated, possibly due to microbial activity and decomposition. Warmer temperatures reduce dissolved oxygen availability, accelerating biological processes. Elevated temperatures may increase the rate of biochemical reactions, impacting DO levels (Henry*et al*., 2023). The EC values are high, ranging from 622µS/cm (Hakonidi) to 820µS/cm (Kofar Dundaye), suggesting a high concentration of dissolved ionic substances (e.g., salts, heavy metals, nutrients). EC exceeding 500µS/cm often reflects pollution from domestic or industrial sources. Similar high EC was reported in wastewater channels in Jos, Nigeria (Henry *et al*., 2023), linked to industrial effluents and urban runoff. DO values are relatively low across sites. The highest value is 5.1 mg/L (Kwalwalawa), while the lowest is 2.1 mg/L (KofarDundaye), suggesting that oxygen levels may not sufficiently support sensitive aquatic life. DO < 4 mg/L is typically considered stressed. Low DO is indicative of microbial degradation of organic matter, a sign of high biochemical oxygen demand (BOD) (Iheukwumere *et al*., 2021). Biochemical Oxygen Demand (BOD) values indicate the amount of biodegradable organic matter present. Higher BOD values (like 5.90 mg/L in Munjawa) indicate higher organic pollution. NESREA recommends BOD < 30 mg/L, so these are moderate but may still affect aquatic ecosystems if sustained. Chemical Oxygen Demand (COD) values (2.91–9.10 mg/L) The COD values across the sites are relatively low to moderate, peaking at 9.10 mg/L (Munjawa). These values, in correlation with BOD, imply moderate levels of organic and chemical pollutants. COD above 10 mg/L indicates significant chemical pollution (Bello *et al*., 2023), thus

your values fall below critical thresholds but remain a concern. Nitrate concentrations range from 0.90 to 6.80µg/L, which are within acceptable limits (WHO guideline: < 50 µg/L). However, higher levels (e.g. 6.80µg/L at Gidan dare) could contribute to eutrophication if combined with phosphate (Table1).

Sulphate (2.60–6.50 µg/L) Sulphate levels are moderate across all sites, with the highest at Munjawa. Though not immediately toxic, sulphate contributes to overall salinity and can cause taste and corrosion problems if levels exceed 250 mg/L in drinking water. Phosphate concentrations (3.00–3.90 µg/L) are above the eutrophication threshold (≥ 0.03 mg/L or 30µg/L). While your units are unclear, if these are in µg/L, they appear low. If in mg/L, the levels are significantly high and pose a major risk of algal blooms. TSS (Total Suspended Solids): Values like 116 (Illa Garage) and 71 (Kwalwalawa) suggest high particulate content. TDS (Total Dissolved Solids): Values from 31 to 176 are within NESREA limits (< 500 mg/L).

Table 2: presents the concentrations of selected heavy metals in wastewater samples collected from ten locations within the study area. The findings demonstrate site-specific variations in heavy metal loads, reflecting differences in anthropogenic activities, industrial discharges, and domestic waste inputs. Chromium (Ch) concentrations ranged from 0.04 ppm (KofarYari) to 0.09 ppm (Ilela Garage). These levels are below the WHO permissible limit for Cr in wastewater (0.1 ppm) (World Health Organization, 2017), indicating minimal chromium contamination. However, slightly elevated values at sites like Illelah Garage may be linked to mechanical workshops or tanneries, which are known contributors of chromium to effluents (Ali *et al*., 2022). Lead (Pb) concentrations were detected between 0.00 ppm and 0.06 ppm, with the highest recorded in Hakonidi, Sokoto State University and Kofar Gundaye. Though these values remain below the WHO maximum contaminant level for Pb in wastewater (0.1 ppm), the presence of lead is still concerning due to its cumulative toxicity. Lead presence may stem from battery disposal, paints, or plumbing systems (Adewumi *et al*., 2021). Cadmium (Cd) was consistently low across all sites, ranging from 0.00 ppm to 0.02 ppm, aligning with WHO's threshold of 0.01 ppm. Notably, Marmarun nupawa and Gidan dare recorded slightly elevated Cd levels above the WHO guideline. Prolonged exposure to such concentrations even if mild, may pose health risks and suggests ongoing cadmium-based discharges, possibly from pigments or fertilizers (Ishaku *et al*., 2020). Iron (Fe) exhibited significant variability, with concentrations ranging from 0.12 ppm (Kofar kware) to 0.81 ppm (Illelah Garage). Although not immediately toxic, high iron levels may cause discoloration and odor in water and affect aquatic ecosystems. The highest values were observed at sites likely affected by rusting pipelines and industrial runoff, consistent with findings by Musa *et al*. (2023), who reported elevated Fe in wastewater from semi-urban areas in Northern Nigeria. Zinc (Zn) levels ranged from 0.25 ppm (Munzawa) to 2.30 ppm (Ilela Garage), with values at most sites approaching the WHO maximum limit (3.0 ppm). Zinc is commonly introduced into wastewater via galvanized materials, paints, and batteries. Although zinc is essential in trace amounts, higher levels may be toxic to aquatic life. The high values at Kofar kware (2.50 ppm) and Illelah Garage (2.30 ppm) may indicate industrial contributions (Okoro *et al*., 2022). Copper (Cu) was present in all samples, with concentrations ranging from 0.85 ppm (Munzawa) to 4.05 ppm (Kwarin Lawa), exceeding the WHO permissible limit of 2.0 ppm in most locations. This indicates significant copper pollution, likely associated with metal finishing industries, plumbing corrosion, and pesticide use (Usman *et al*., 2021). Particularly, Kofarkware, Gidan dare, and Illelah Garage showed alarming levels above regulatory thresholds.

Identified Microalgae

The microalgal species identified from the waste water were presented in **Table 3**. Their classification into different classes is based on morphological characters. A total of eighteen (18) algal species were identified, out of which Ten (12) species belong to the Class Chlorophyceae with *Chrlorellasp* having the highest (4) number of occurrence, two (2) species belong to the Class Cyanophyceae with *Oscillatoria sp* having the highest (3) number of occurrence among the class of Cyanophyceae whereas two (2) species belong to the Class Bacillariophyceae (*Uroglenasp and Ulthrixsp*) and Class Euglenopyceae (*Euglena* sp and *Lepocinlis* sp). Chlorophyta accounted for the majority of species isolated (**Plate 1**), including *Chlorella* sp., *Scenedesmus* sp., and *Ulothrix* sp. These genera are known for their high lipid accumulation potential, making them ideal candidates for biofuel production, wastewater treatment, and carbon sequestration (Rajak *et al*., 2021; Ghosh *et al*., 2023). *Chlorella* species were found across four sites, aligning with their known ecological versatility and growth in nutrient-rich waters (Udom *et al*., 2020). The presence of lipid-rich green microalgae such as *Chlorella* sp. and Scenedesmus sp. across multiple wastewater sources suggests these environments can serve as cost-effective, sustainable cultivation platforms for biomass production (Nwoba *et al*., 2023). Furthermore, the diversity observed supports the assertion that untreated or partially treated

wastewater offers a suitable medium for the proliferation of native microalgae strains capable of bioenergy applications (Obe*et al*., 2022).

Biomass Concentration (gL^{-1} dry weight) of Microalgae Species at 12 Days and Lipid Content and Lipid Productivity from Microalgae species

The results of Biomass Concentration (gL^{-1} dry weight) of Microalgae Species at 12 Days and Lipid Content and Lipid Productivity from Microalgae species were presented in tables 4 and 5

Table 3. Identified Microalgae Species from Waste Water Sample

S/NO	Collection site	Species	Division
1	Buzaye	*Scenedesmus sp*	Chlorophyta
2		*Coelastriumsp*	Chlorophyta
3		*Gyosigmasp*	Chlorophyta
4		*Chroocuccussp*	Cynophyta
5		*Lepocinclissp*	Euglenophyta
6		*Oscillatoria sp*	C Cynophyta
7		*Chlorella sp*	Chlorophyta
8	**Kwalkwalawa**	*Botrydiopsissp*	Chlorophyta
9		*Botryococcussp*	Chlorophyta
10		*Chlorella sp*	Chlorophyta
11	**Helele**	*Botryococcus*	Chlorophyta
12		*Oscillatoria sp*	Chlorophyta
13	**Kofardundaye**	*Euglena*	Euglenophyta
14	**Sokoto State university**	*Nil*	Nil
15	**Hokonidi**	*Zygenemasp*	Chlorophyta
16		*Closteruimsp*	Chlorophyta
17		*Uroglenasp*	Bacillariophyta
18	**Gidan dare**	*Ulothrixsp*	Chlorophyta
19		*Closteruimsp*	Chlorophyta
20		*Chlorella sp*	Chlorophyta
21	**Ilelela garage**	*Tetraspora cylindrical*	Chlorophyta
23		*Scenedesmus sp*	Chlorophyta
24		*Pediastrum sp*	Chlorophyta
25	Kofarkware	*Oscillatoria sp*	Cynophyta
26		*Chlorella sp*	Chlorophyta
27		*Chlococcumsp*	Chlorophyta
28	M/nupawa	*Oocystessp*	Chlorophyta
29		*Uroglenasp*	Bacillariophyta

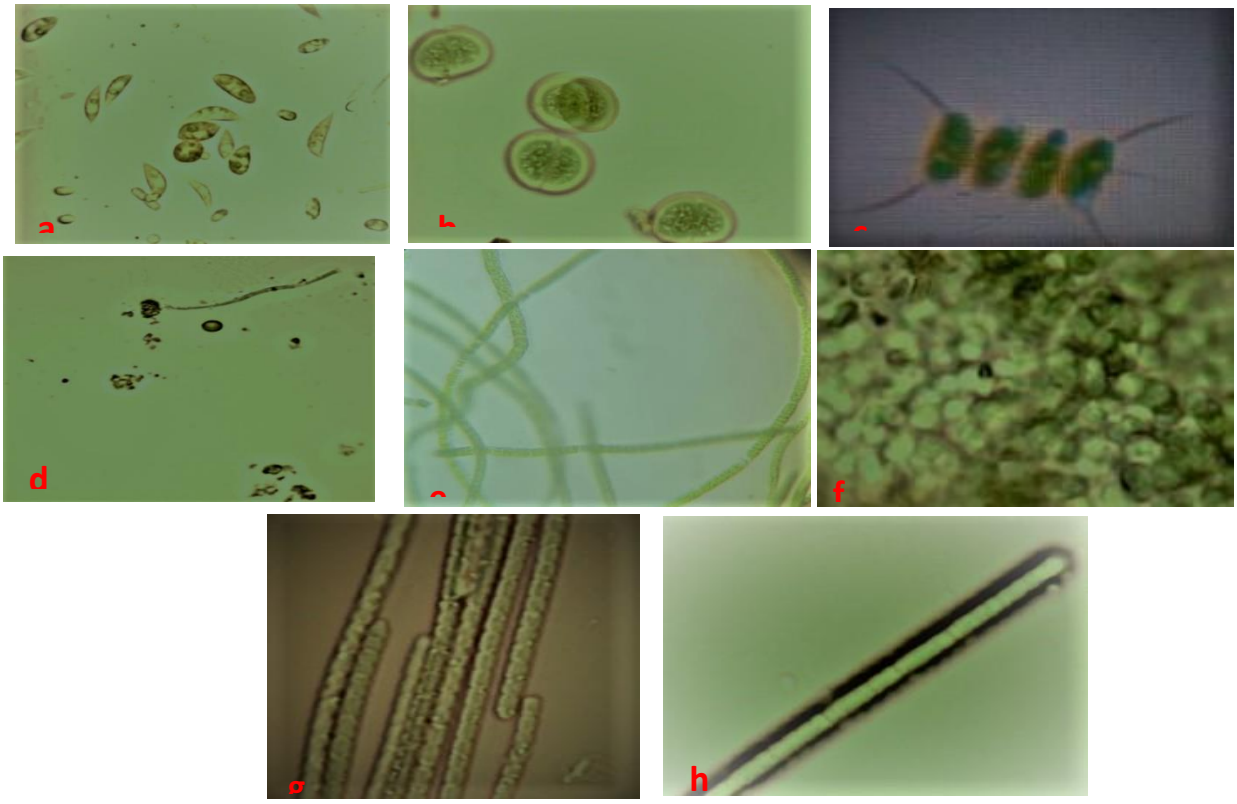

Plate 1. Photo of some of the representative of microalgae isolates from wastewater in Sokoto
(a) *Botryococcus* (b) Chlorealla, (c)Scenedesmus, (d)Coelastrum, (e) Oscillatoria (f)Oocystis (g)Ulothrix, (h)*Tetraspora cylindrical*

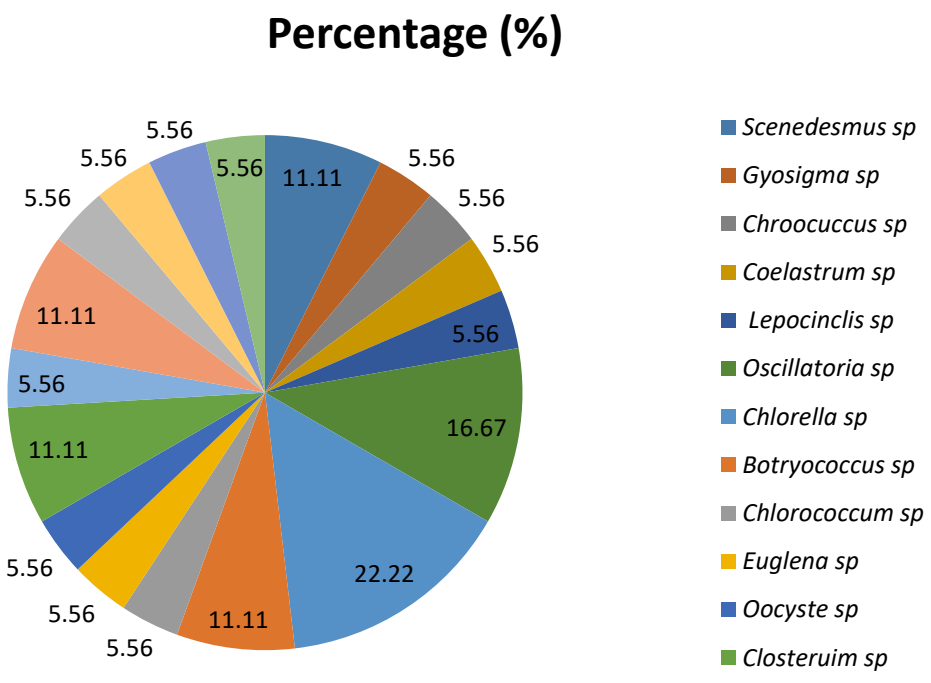

Fig. 2. Frequency of occurrence for the microalgae species isolated from the wastewater

Table 4. Biomass Concentration (gL^{-1} dry weight) of Microalgae Species at 12 Days

Microalagae species	Biomass Concentration (gL^{-1} dry weight)	Biomass productivity ($gL^{-1}d^{-1}$)
Scenedesmus sp	2.61±0.01	0.22±0.09
Gyosigmasp	1.24±0.04	0.10±0.00
Chroocuccussp	0.58±0.13	0.04±0.10
Coelastrumsp	1.20±0.04	0.10±0.20
Lepocinclissp	1.21±0.01	0.10±0.03
Oscillatoria sp	0.16±0.60	0.01±0.09
Chlorella sp	2.07±0.02	0.17±0.12
Botryococcussp	1.96.±0.30	0.16±0.03
Chlorococcumsp	0.47±0.14	0.04±0.04
Euglena sp	1.02±0.10	0.09±0.30
Oocystesp	0.72±0.12	0.06±0.01
Closteruimsp	0.84±0.02	0.07±0.02
Zygnemasp	0.41±0.09	0.03±0.12
Uroglenasp	0.59±0.50	0.05±0.05
Ulthrixsp	0.92±0.01	0.08±0.07
Tetraspora cylindrical	0.62±0.08	0.05±0.11
Pediastrum sp	0.99±0.70	0.08±0.06
Botrydiopsissp	1.06±0.03	0.09±0.01

Table 5. Lipid Content and Lipid Productivity from Microalgae species

Microalgae species	Lipid content (%)	Lipid productivity (gL^{-1} d)
Scenedesmus sp	38.57±0.18	0.57±0.03
Gyosigmasp	29.20±0.07	0.34±0.13
Chroocuccussp	09.15±0.05	0.44± 0.21
Coelastrumsp	24.82±0.01	0.40±0.09
Lepocinclissp	20.69±0.20	0.48±0.07
Oscillatoria sp	22.17±0.03	0.05±0.06
Chlorella sp	28.18±0.04	0.60±0.05
Botryococcussp	30.27±0.20	0.53±0.04
Chlorococcumsp	17.00±0.08	0.24±0.01
Euglena sp	23.01±0.16	0.39±0.03
Oocystesp	10.41±0.07	0.58±0.02
Closteruimsp	17.18±0.21	0.41±0.01
Zygnemasp	10.72±0.09	0.28±0.31
Uroglenasp	18.35±0.02	0.27±0.21
Ulthrixsp	11.68±0.06	0.68±0.11
Tetraspora cylindrical	08.02±0.13	0.62±0.13
Pediastrum sp	09.53±0.09	0.84±0.20
Botrydiopsissp	21.26±0.21	0.42±0.01

The study evaluated the biomass concentration and productivity of different indigenous microalgae species isolated from wastewater over a 12-day cultivation period (**Table 4**). Among the analysed species, Scenedesmus sp. demonstrated the highest biomass concentration, and productivity reaching 2.61±0.01g/L and 0.22±0.09$gL^{-1}d^{-1}$on Day 12, indicating superior growth and productivity under the given culture conditions. Scenedesmus sp. is well-known for its robust adaptability and tolerance to wastewater environments, making it an excellent candidate for large-scale biomass and biofuel applications. The high productivity observed is consistent with the findings of Sharma *et al*. (2021), who reported that Scenedesmus obliquus can thrive in high-nutrient and variable pH environments, contributing to its efficient biomass accumulation. Similarly, Ratha *et al*. (2022) highlighted the species' ability to utilize wastewater nutrients

effectively, promoting sustainable biofuel production. The dominance of Scenedesmus sp. could be attributed to its high nutrient uptake rate, efficient photosynthesis, and dense cell wall that enhances biomass stability (Koley *et al*., 2020).

The lipid content and productivity of the isolated microalgae species varied significantly (**Table4)**, indicating differences in their potential as biodiesel feedstock. Among all the isolates, Scenedesmus sp recorded the highest lipid content (38.37 ± 0.18%) and lipid productivity (0.75 ± 0.03 $g/L^{-1}{\cdot}d^{-1}$), making it the most promising candidate for biodiesel production. This agrees with findings by Patel *et al*. (2021) and Khan *et al*. (2023), which highlighted Scenedesmus spp. as efficient lipid accumulators under nutrient stress. *Botryococcus* sp also exhibited a high lipid content (30.27 ± 0.20%) and lipid productivity (0.53 ± 0.04 $g/L^{-1}{\cdot}d^{-1}$), supporting earlier research by Sivaramakrishnan *et al*. (2022) that emphasized *Botryococcus braunii* as a viable strain due to its hydrocarbon-rich oil. Chlorella sp showed a lipid content of 28.18 ± 0.04% and lipid productivity of 0.60 ± 0.05 $g/L^{-1}{\cdot}d^{-1}$, further confirming its industrial potential, as widely reported in the literature (Rani and Tripathi, 2020; Shetty *et al*., 2021). *Tetraspora cylindrical* also performed well with lipid productivity of 0.62 ± 0.13 g/L·d, despite its lower lipid content (8.02 ± 0.13%), implying its fast growth rate might compensate for lower lipid accumulation. On the other hand, species like *Zygnemasp* (10.72 ± 0.09% lipid content, 0.73 ± 0.31 g/L·d) and *Euglena sp* (23.01 ± 0.16%, 0.58 ± 0.18 g/L·d) had lower lipid percentages but still demonstrated substantial productivity. This may be due to higher cell densities or faster growth rates, a trend also reported by Hadiyanto *et al*. (2021). Interestingly, *Pediastrum sp* had one of the lowest lipid contents (9.35 ± 0.09%) but recorded relatively high productivity (0.84 ± 0.20 g/L·d), suggesting its potential under optimized culture conditions.

CONCLUSION

This study demonstrated significant variations in physicochemical and heavy metal concentrations across sampling sites, with KofarDundaye showing the highest electrical conductivity and Buzaye having the highest nitrate and zinc concentrations. Multiple microalgae species, predominantly from the phylum Chlorophyta, were successfully isolated from untreated wastewater. Amongst all the isolates, Scenedesmus sp. exhibited the highest biomass concentration and productivity, indicating strong potential for bioremediation and biofuel feedstock development using wastewater as a growth medium.

REFERENCES

Abdel-raouf, n., al-homaidan, A. A., andIbraheem, I. B. (2012). Microalgae and wastewater treatment. Saudi journal of biological sciences, 19(3), 257–275.

Adewumi, A. A., Osibanjo, O., andBada, S. O. (2021). Assessment of heavy metal contamination in urban water bodies in Nigeria. *Environmental research communications*, 3(4), 045001. Https://doi.org/10.1088/2515-7620/abf0a3

Adeyemi, A. O., Ogunbanjo, O. A., and Lawal, T. A. (2023). Comparative analysis of lipid productivity and nutrient removal by microalgae species cultivated in wastewater. *Cleaner engineering and technology*, 10, 100553. Https://doi.org/10.1016/j.clet.2023.100553

Adeyemo, F. E., Adebayo, T. A., andOlagunju, O. A. (2022). Diversity and abundance of microalgae in untreated wastewater: implications for biofuel production. *Bioresource technology reports*, 19, 101125. Https://doi.org/10.1016/j.biteb.2022.101125

Ado, G., Haruna, H, and Indabawa, I.I.(2018). Response of some Cyanobacterial species for adsorption of manganese, cobalt and nickel from untreated tannery effluent in kano. *Bayero Journal of Pure and Applied Sciences*, 11(1): 179 - 182

Ali, A., Muhammad, M., andGarba, M. (2022). Chromium pollution from tannery effluents in northern Nigeria: implications for water safety. *Journal of environmental protection*, 13(3), 154–164. Https://doi.org/10.4236/jep.2022.133009

American Public Health Association (APHA) (1998). Standard Methods for the Examination of water and Waste water 20th ed. Washington. APHA; 1220.

Bello, O. O., Akinpeloye, B. O., Bello, T. K., Oluwafemi, Y. D., andOsungbemiro, B. W. (2023). Evaluation of the physicochemical properties and bacterial loads of selected Rivers in Ondo State,Nigeria. *Iranian journal of microbiology*, 15(6), 788–795. Https://doi.org/10.18502/ijm.v15i6.14537.

Chisti, Y. (2007). Biodiesel from microalgae. *Biotechnology advances*, 25(3), 294–306.

Chisti, Y. (2007). Biodiesel from microalgae. *Biotechnology Advances*, 25(3), 294–306. https://doi.org/10.1016/j.biotechadv.2007.02.001

Demirbas, a. (2011). Biodiesel from microalgae Oil. Energy education science and technology part a: *Energy Science and Research*, 27(1), 69–76.

Emmanuel T. S., Nqobizitha S. A., Tavengwa B.B. and Ryman, S. (2021). Isolation and screening of microalgal species, native to Zimbabwe, with potentialuse in biodiesel production. ALL LIFE VOL. 14, NO. 1, 256–264 https://doi.org/10.1080/26895293.2021.1911862

Ghosh, A., Islam, M. A., andWang, H. (2023). Advances in green microalgae-based biodiesel production from

wastewater: a review. Renewable and sustainable energy reviews, 170, 113010. Https://doi.org/10.1016/j.rser.2022.113010

Guiry, M. D., Guiry, G. M., Morrison, L., Rindi, F., Miranda, S. V., Mathieson, A. C., and Garbary, D. J. (2017). AlgaeBase: an on-line resource for algae. *Cryptogamie, Algologie*, *35*(2), 105-115.

Gupta, S. K., Singh, R., andPrasad, R. (2020). Role of euglena spp. In bioremediation and sustainable energy production. Environmental technology and innovation, 18, 100776. Https://doi.org/10.1016/j.eti.2020.100776

Hadiyanto, H., Cahyono, R. B., andCahyaningrum, D. (2021). Effect of nutrient and light intensity on lipid accumulation of microalgae for biodiesel production. IOP conference series: *Earth and environmental science*, 716(1), 012020. Https://doi.org/10.1088/1755-1315/716/1/012020

Henry, M. U., Henry, I. U., Obidola, S. M., Dogun, O., Ogenyi, R. A., Akintunde, S., andLekduhur, J. (2023). Assessment of the physicochemical parameters and heavy metal concentration of Delimiwastewater in Jos North Local Government Area, Plateau state. *UMYU Scientifica*, 2(4), 76–84.

Iheukwumere, S. O., Phil-Eze, P. O., andNkwocha, K. F. (2021). Seasonal variability and wastewater treatment efficiency in federal capital territory, Abuja. *International journal of environmental chemistry,* 5(2), 31–37. Https://doi.org/10.11648/j.ijec.20210502.13

Ishaku, J. M., Musa, A. M., andHaruna, Y. (2020). Distribution of cadmium and lead in selected wastewater systems of north-western Nigeria. *Environmental monitoring and assessment*, 192, 336. Https://doi.org/10.1007/s10661-020-08268-3

Khan, A. U., Ahmed, I., andRehman, S. (2023). Microalgae as next-generation biofuel feedstock: a review on cultivation, lipid extraction, and recent developments. *Renewable and sustainable energy reviews*, 177, 113235. Https://doi.org/10.1016/j.rser.2023.113235

Koley, S., Ratha, S. K., Prasanna, R., and Saxena, A. K. (2020). Evaluation of scenedesmus sp. For biomass and lipid productivity using wastewater as a growth medium*. Journal of environmental management,* 271, 110944.
Https://doi.org/10.1016/j.jenvman.2020.110944

Lee, J. H., Kim, S. Y., and Park, J. M. (2023). Optimized growth conditions for enhanced lipid production in scenedesmus spp. Bioresource technology reports, 22, 101097. Https://doi.org/10.1016/j.biteb.2023.101097

Mata, T. M., Martins, A. A., and Caetano, N. S. (2010). Microalgae for biodiesel production and other applications: A review. *Renewable and Sustainable Energy Reviews*, 14(1), 217–232. https://doi.org/10.1016/j.rser.2009.07.020

Musa, Y. A., Ibrahim, A., and Idris, S. (2023). Iron contamination in wastewater of semi-urban settlements: sources and risks. Heliyon, 9(3), e14052. Https://doi.org/10.1016/j.heliyon.2023.e14052

Nwoba, E. G., Moheimani, N. R., and Raheem, A. (2023). Wastewater-grown microalgae for biofuel and value-added products: recent trends and future outlook. Journal of environmental chemical engineering, 11(4), 110162. Https://doi.org/10.1016/j.jece.2023.110162

Obe, E. A., Ibrahim, H. D., and Sulaiman, A. A. (2022). Isolation and characterization of native microalgae strains from domestic wastewater in northern Nigeria. *African journal of biotechnology*, 21(12), 200–210. Https://doi.org/10.5897/ajb2022.17432

Okoro, H. K., Adebayo, A. O., and Olatunji, O. S. (2022). Environmental impact assessment of heavy metal pollution from urban drainage systems. *Science of the total environment*, 806, 150426. Https://doi.org/10.1016/j.scitotenv.2021.150426

Omoigberale, M. O., Ezenwa, I. M., Biose, e., and Otobrise, o. (2020). Spatial variations in the physico-chemical variables and macro-benthic invertebrate assemblage of a tropical river in nigeria. Arxiv preprint arxiv:2006.11664. Https://arxiv.org/abs/2006.11664

Othman, M., Abdullatif, A., and Harun, R. (2021). Screening of indigenous microalgae strains from wastewater for lipid production and co2 mitigation. Sustainable environment research, 31, 25. Https://doi.org/10.1186/s42834-021-00088-y

Patel, A., Singh, N. K., and Ghosh, P. K. (2021). Lipid productivity and fatty acid profile of scenedesmus spp. For biodiesel production. *Energy* reports, 7, 1326–1333. Https://doi.org/10.1016/j.egyr.2021.01.005

Rajak, R. C., Patel, A., and Kumar, D. (2021). A comprehensive review on potential use of microalgae for biofuel production. Science of the total environment, 798, 149279. Https://doi.org/10.1016/j.scitotenv.2021.149279

Rani, S., and Tripathi, V. (2020). Comparative analysis of lipid productivity in chlorella sp. Under nitrogen stress for biodiesel production. *Biofuels*, 11(8), 873–881. Https://doi.org/10.1080/17597269.2018.1538523

Ratha, S. K., Koley, S., Prasanna, R., Saxena, A. K., and Paul, D. (2022). Microalgal valorization of wastewater and its implications for biofuel production. *Renewable and sustainable energy reviews*, 158, 112144. Https://doi.org/10.1016/j.rser.2022.112144

Rawat, I., Ranjith Kumar, R., Mutanda, T., and Bux, F. (2011). Dual role of microalgae: phycoremediation of domestic wastewater and biomass production for

sustainable biofuels production. *Applied energy*, 88(10), 3411–3424.

Sharma, K., Dhar, D. W., and Jassal, V. (2021). Potential of scenedesmus obliquus in biomass and lipid accumulation under mixotrophic cultivation using industrial effluents. Algal research, 58, 102394. Https://doi.org/10.1016/j.algal.2021.102394

Shetty, P., Venkata Mohan, S., and Sindhu, R. (2021). Biofuel potential of chlorella species under varying cultivation strategies: A review. Fuel, 289, 119843. Https://doi.org/10.1016/j.fuel.2020.119843

Sivaramakrishnan, R., Incharoensakdi, A., and Prasertsan, P. (2022). An overview of botryococcus sp. For biofuel and high-value product applications. Algal research, 65, 102735. Https://doi.org/10.1016/j.algal.2022.102735

Udom, I., Zaribaf, B. H., and Anderson, L. (2020). Evaluation of green microalgae for wastewater treatment and renewable energy generation. Environmental progress and sustainable energy, 39(2), e13326. Https://doi.org/10.1002/ep.13326

Usman, M. S., Zubairu, S. M., and Abdullahi, M. M. (2021). Pollution load index and ecological risk assessment of heavy metals in Nigerian wastewater effluents. *International journal of environmental science and technology*, 18, 3219–3230. Https://doi.org/10.1007/s13762-020-03001-0

Wang, H., Gao, L., Chen, L., Guo, F., and Xu, C. (2019). Energy-efficient microalgae harvesting using bacterial bioflocculant: Co-culture of microalgae with floc-forming bacteria as a novel bioflocculation strategy. *Bioresource Technology*, 280, 59–65.

World Health Organization (who). (2017). Guidelines for drinking-water quality (4th ed.). Who press.

Zainal, A., Abubakar, N. S., and Jamil, N. (2022). Indigenous Microalgae from wastewater: a sustainable approach for biomass and lipid production. *Journal of cleaner production*, 337, 130487. Https://doi.org/10.1016/j.jclepro.2022.130487.