

ABSTRACT

In this study *Chlorella vulgaris*, *Rhizoclonium hieroglyphicum* and mixed algae culture (*Microspora* sp., *Navicula* sp., *Lyngbya* sp., *Cladophora* sp., *Spirogyra* sp. and *Rhizoclonium* sp.) were used with the objective of treating municipal wastewater and biodiesel production from harvested biomass of algae. Algal species were collected from different sites of Lahore and their growth rate was monitored for eight days by growing in various culture media i.e. agar solution, synthetic medium and wastewater. *R. hieroglyphicum* showed high growth rate in both synthetic medium ($1.5 \text{ g.L}^{-1}.\text{day}^{-1}$) and wastewater ($0.75 \text{ g.L}^{-1}.\text{day}^{-1}$) while growth rate of *C. vulgaris* and mixed algae culture in wastewater was $0.55 \text{ g.L}^{-1}.\text{day}^{-1}$ and $0.6 \text{ g.L}^{-1}.\text{day}^{-1}$ respectively. Comparison of growth rate in various culture media by selected species of algae showed higher growth rate in synthetic medium followed by wastewater then in agar solution.

Wastewater was characterized for various parameters i.e. Chemical oxygen demand (COD), Biochemical oxygen demand (BOD), Total solids (TS), Total dissolved solid (TDS), Total suspended solids (TSS), Total phosphorus (TP), Total Kjeldhal nitrogen (TKN), Nitrate ($\text{NO}_3\text{-N}$), Phosphate (PO_4) and Chlorides (Cl^-) and reduction in the concentrations of these parameters was measured by treating with selected algae in ponds of various dimensions (P1, P2, P3 & P4) by changing hydraulic retention time (2-8 days) and weather conditions (January to December). It was found that reduction in the concentration of selected parameters was almost similar in P2 and P4 but higher than P1 and P3. Reduction was increased from 2nd to 8th day of hydraulic retention time. Comparison of reduction in various months showed higher reduction in the month of November. Maximum reduction in the concentrations of wastewater parameters was shown by *C. vulgaris* i.e. COD (98.27%), BOD (98.7%), TKN (93.14%), TP (98%), $\text{NO}_3\text{-N}$ (98.33%), PO_4 (98.64%), SO_4 (97.27%), Cl^- (94.17%), TC (99%), FC (99%) and TDS (98.22%) while maximum reduction in TSS (91.95%) was measured in mixed algae culture pond. A lab scale biological treatment system consisting of screening, sedimentation, filtration and chlorella treatment pond was also designed using the most efficient algae i.e. *C. vulgaris*. Analysis of selected parameters at final stage of biological treatment system showed maximum reduction percentage of COD (99.9%), BOD (100%), $\text{NO}_3\text{-N}$ (99.98%), PO_4^{2-} (99.96%) and TC (100%) by applying *C. vulgaris*.

Biomass of selected algae was harvested and analyzed for various parameters (carbohydrates, protein & lipid contents) to determine its suitability for biodiesel production and it was found that *C. vulgaris* showed higher lipid contents (45 ± 1.9) followed by mixed algae culture (35 ± 2.8) then *R. hieroglyphicum* (34 ± 0.9). Oil was extracted from dried biomass using different solvents (acetone, hexane and methanol) and hexane was found efficient solvent at extraction time of 240 minutes with methanol to oil molar ratio of 3:1. Extracted oils were analyzed for various parameters (fatty acid composition, pH, water contents, iodine value, saponification value, free fatty acids and acid number). Unsaturated fatty acids were higher in oil extracted from all selected algae making it suitable for biodiesel production.

Biodiesel was synthesized from algal oil using various catalysts (Na, NaOH, KOH & H₂SO₄) and its properties such as density, kinematic viscosity, flash point, specific gravity, cetain number, acid number, water contents and calorific value were analyzed to check its quality. Biodiesel production from algal oil showed maximum production (93.93%) by *C. vulgaris*. Comparison of catalysts in terms of biodiesel yield from dried algal biomass showed maximum yield (48.2%) with 1.5% concentration of Na metal catalyst in reaction time of 60 minutes. Quality analysis of biodiesel showed that good quality biodiesel was synthesized in the presence of Na metal catalyst with following characteristics; density (0.87 kg/l) kinematic viscosity (5.2 mm²/s), flash point (145 °C), specific gravity (0.916 g/ml), cetain number (53 min), acid number (0.37 mg.KOH/g), water contents (0.04 %vol) and calorific value (41.2 MJ/Kg). These properties were in accordance with ASTM standard limits thus proving its quality.