

## REVIEW

**on the dissertation on "Assessment of Biodiversity of Microalgae in Almaty region: Morphological and Metagenomic Exploration" prepared for the degree of Doctor of Philosophy (PhD) in 6D070100 - "Biotechnology"**

I am writing this document presenting brief review of research, findings and dissertation of my PhD student, Ms. Huma Balouch, as part of requirements for doctoral degree on speciality 6D070100 – Biotechnology, titled 'Assessment of Biodiversity of Microalgae in Almaty region: Morphological and Metagenomic Exploration.

Her study focused on the promising role that microalgae can play in Kazakhstan's sustainable bio-economy of the future, outlining the cellular functions, health benefits, and industrial applications of microalgae as a renewable feedstock for the production of biofuel, providing novel metabolites with antibiotic activity, and as a remediation agent in environmental applications. Ms. Huma Balouch explored the diversity of freshwater microalgae in Almaty region to find strains with high percentage of lipids for biofuel production, antagonistic activity against wide range of bacteria, and for bio-monitoring purpose.

The purpose of her research was to study the fatty acids profile and composition of selected microalgae strains using Gas chromatography mass spectrometry (FAMES) analysis that can be used as a precursor for biofuels, investigating potential broad spectrum antibacterial activity using disk diffusion assay, and examining the interference of heavy metals pollution with process of microalgal cells at cellular and subcellular level using transmission electron microscopy and fluoroscopic methods. She assessed the enormous amount data generated from processes such as microalgae cultivation and new species screening and evaluation, Inter transcribed spacer (ITS) region and ribulose-bisphosphate carboxylase gene (*rbcL*) gene sequence, the combination of methods for lipids extraction and fatty acids profiling.

The fatty acids profile of isolates was found dominated by palmitic acids C16 :0; stearic acids C18 :0; oleic acids C18 :1, which is consistent with previous research in the field of biofuel production that biomass oil used for biodiesel production have to contain rich content of fatty acids C16 and C18.

Four strain exhibited impressive antibiotic properties against gram negative and gram positive bacteria with few µg/mL MIC value. Moreover, the methanol extracts of *Monoraphidium sp.* ZBD-06 (psychrophilic strain) exhibited the notable antibacterial activity against *Klebsiella pneumoniae*, which indicates its potential as prolific source of structurally diverse novel bioactive metabolites. The study unveiled that solvent extraction of microalgae strains with 60% methanol is an effective strategy and method to find their antibacterial potential.

Her research work illustrated that microalgae cells use biosorption and bioaccumulation as main mechanisms for metal detection and removal from the environment. In her study, heavy metals appear to have more inhibitory effects than stimulatory on the microalgae cells depending on metal concentration.

She designed her research methodology very carefully and presented in enough detail that this work can easily be replicated by other researchers. The results of the study have been reasonably strengthened by reference to existing research in the field. Her work and dissertation has clearly articulated the overall aims of the study and demonstrated reliable results. The research findings have been presented in a way that is consistent with accepted practice in the relevant field

of study. The dissertation write-up is with clarity, simplicity and accuracy and has a logical flow. Her work was very systematically undertaken using several molecular, biochemical, and biological techniques and methods, providing precise interpretation of data and drawing appropriate conclusions from the obtained results. The methods were effectively employed to select microalgae species from environmental samples and also to screen suitable phenotypes with high neutral lipid suitable for biofuel production from considerable number of isolates, within a reasonably short time.

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