Chapter 19
Common Duckweeds as a Model System for Climate Change Impact Assessment

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ABSTRACT

Common duckweeds – Lemna – are free-floating aquatic macrophytes belonging to Lemnaceae family. They occur universally, in tropical and temperate zones and are enabled to grow in stagnant, slow-flowing, nutrient-enriched waters. They have an ability to grow over a wide range of temperatures (6 – 33 ^{0}C) and pH (optimum 5.5 – 7.5). Lemna species also manifest a characteristic macrophyte community in association with plants functioning as a dominant primary producer. Asexual mode of reproduction is exclusive and therefore, all resources are directed towards vegetative growth. Structure wise they show leaflets (frond) and root-like diffuse form. This simple morphological and physiological form offers special scientific and engineering properties – reflected in easy handling and manipulation under laboratory conditions. As a result they are regarded as a model plant system for a number of chemical and biogeochemical studies. Climate change affects plant growth and physiology. For example, increasing atmospheric concentrations of carbon dioxide (CO_2) and ozone (O_3) or increase in ultraviolet (UV) radiation (due to the thinning of the ozone layer) can have pronounced effects on the growth and development of plants. In many instances the decrease in growth rate can create disturbances in photosynthetic processes. In the recent past there has been a surge in the interest in looking for alternative remediation technologies to meet formidable demands of polluting materials and situations. One such approach i

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s phytoremediation – the use of plants and associated microbes for environmental cleanup. Cardinal points in favour of such an approach are – cost-effectiveness, natural energy-driven and minimal capital and running costs. Potency of Lemna spp. as a phytoremediation agent as well as its limitations haven dealt with in details in literature. Moreover, Lemna spp. are accepted and highly standardized as test organisms in aquatic ecotoxicology. The authors have shown earlier that Lemna spp. can play a vital role in combating pollution burden in a glaring local situation of river pollution. However, the recent trend in research indicates that Lemna spp (duckweeds at large) can play a critical and sensitive role in being an indicator of overt and subtle climate change. The following is an attempt to take a review of such recent trends.

INTRODUCTION

Duckweed in Bloom: .... heralds the return of a plant model for plant biology (Lam et al., 2014)

The authors would wish to thank profusely Lam et al. (2014), for the liberty to transform the title of their paper into a quote since it so well befits the purpose of this review!

Duckweeds are the simplest and smallest flowering plants that are ubiquitous and happily growing on fresh or polluted water. They have been curious objects of the intense research to understand the plant and their potentials – especially in genetics and biochemical repertoire. This is comparable to drosophila (fruit flies), bread moulds, *Escherichia coli* and *Saccharomyces* which have been proven workhorses. Small, fragile and free-floating duckweeds grow on mud or water depths up to 3 metres. Optimum nutrient concentrations support rapid growth.

Duckweeds are classified under family Lemnaceae which contains five genera, viz., *Lemna*, *Spirodela*, *Landoltia*, *Wolffia*, and *Wolfella*. All species under these genera are commonly designated as duckweeds. There are more than 40 species in these genera spread over the entire world. The genus *Lemna* contains nine species, viz., *L. aequinoctialis* (lesser duckweed); *L. gibba* (swollen duckweed); *L. minor* (common duckweed); *L. minuta* (least duckweed); *L. obscura* (little duckweed); *L. triscula* (star duckweed); *L. turionfera* (turion duckweed); and *L. valdiviana* (valdivia duckweed).

Duckweeds are manifested worldwide – tropical to cold regions but without extremes of cold, dryness or wetness. They prefer to inhabit small and shallow water bodies – e.g., ponds, pools, small lakes, ditches and wetlands. Such ecosystems occur world-wide and are full of biodiversity. It is necessary for the duckweeds to have nutrient supply in the water column as they are free-floating. Nutrient conditions are rich in small and shallow environments located in agricultural areas which tend to support dense mats. However, at times such dense growth may lead to several consequences such as interference in exchange of oxygen, restrict photosynthesis under the mat and create anoxic conditions to seriously affect macro-invertebrates and fishes. Freshwater ecosystems in arctic can be varied with respect to type, physical and chemical characteristics and associated biota. Also two major freshwater ecosystems exist – lotic (flowing water) and lentic (standing water). Large variations can exist in size, characteristics and location resulting into similar wider responses to climate change.

The morphology of duckweeds is simple. All members have flattened minute leaf like oval to round "fronds" *ca*. 1 mm to less than 1 cm across. Some members are endowed with root like structures which in open water either help to stabilize or assist to procure nutrients whenever these are in low concentrations.