Functional role of dissolved oxygen as TEA-Towards treatment of multiple pollutants

Domestic or industrial effluents need appropriate treatment prior to discharge into the ecosystem. Physicochemical processes have been commonly used for the treatment of wastewater . Alternatively , biological processes are considered to be advantageous and sustainable in comparison to the physicochemical methods due to the cost effectiveness and eco-friendly nature. Biological processes employed to remediate the waste/wastewater face significant challenges while treating complex wastewater. The treatment efficiency of wastewater and its constituents in the biological process gets influenced by the presence of dissolved oxygen (DO) based on its role as terminal electron acceptor (TEA). DO is an essential to oxidize organic content of wastewater and obtain energy for growth specific to the aerobic operation. Irrespective of the reactor microenvironment, carbon will undergo degradation to form end products along with the generation of reduced electron carriers (NAD^+, FAD^+, FMN^+, etc.).

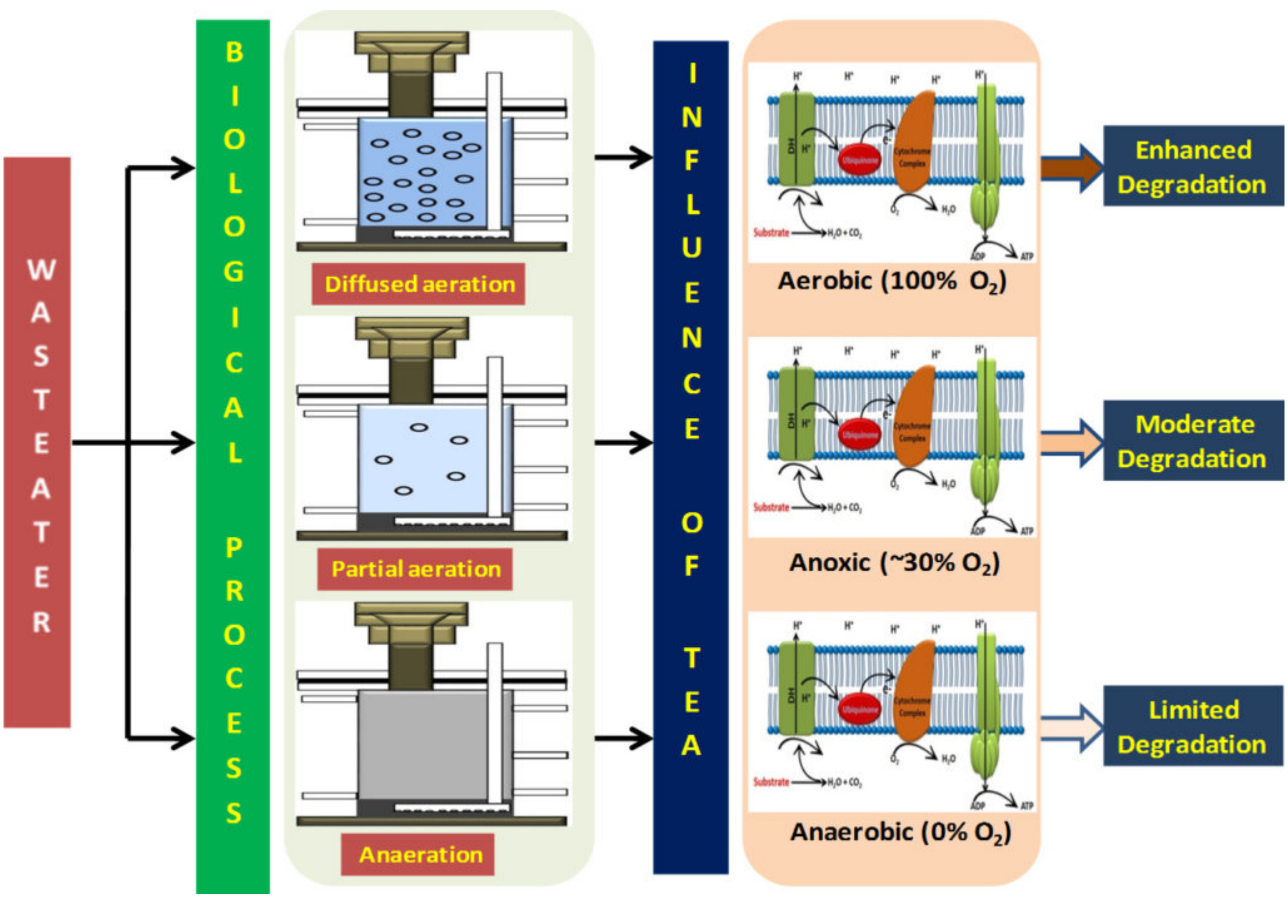

Fig. 1. Schematic representation of biological degradation in PDBR with function of Dissolved Oxygen(DO).

The specific aim of this research is to evaluate the influence of DO on the biological wastewater treatment using three different modes of periodic discontinuous batch systems (PDBR; sequential batch) operated with diverse microenvironments (aerobic, anoxic and anaerobic). Due to flexibility to operate under diverse microenvironments, PDBR was considered for evaluating the role of DO as TEA. PDBR also offers feast and famine conditions in a single biosystem, contrary to the conventional continuous-flow systems and its unique flexibility to combine multiple metabolic functions (redox conditions) during the operation has raised a point of interest, especially in treating low biodegradable and complex wastewaters. PDBR-aerobic and PDBR-anoxic systems were inoculated with aerobic sludge collected from activated sludge process (ASP) while PDBR-anaerobic was inoculated with anaerobic sludge collected from the anaerobic reactor (ETP). Real field crystalline cellulosic (CC) wastewater was used as model wastewater (pH, 1.70; COD, 6900 mg/l; BOD, 2900 mg/l; nitrate, 144 mg/l; phosphate, 23 mg/l; TSS, 317 mg/l; and TDS, 9780 mg/l with BOD/COD ratio of 0.42) for this study.

The function of DO levels as terminal electron acceptor (TEA) on the substrate degradation (COD removal) was quite evident with the varied PDBR operations. The higher COD removal was observed in PDBR-aerobic system [92%; 2.63 kg COD/m^3-day])] compared to PDBR-anoxic [71%; 2.12 kg COD/m^3-day] and PDBR-anaerobic [63%; 1.81 kg COD/m^3-day] systems. Presence of oxygen showed marked influence on the denitrification (nitrates (NO_3^{2-}) removal) [PDBR-aerobic (59%); PDBR-anoxic (39%); PDBR-anaerobic (29%)]. Complete removal of phosphate ($PO_4^{3+;}$ 23 mg/l) was noticed in all the conditions studied by the end of 24 h. Multi-scan spectral profiles showed the significant reduction in the colour intensity in all three microenvironments. The dehydrogenase (DH) enzyme activity of biocatalyst was observed to be driven by the presence of O_2 as TEA, influencing the COD degradation pattern.

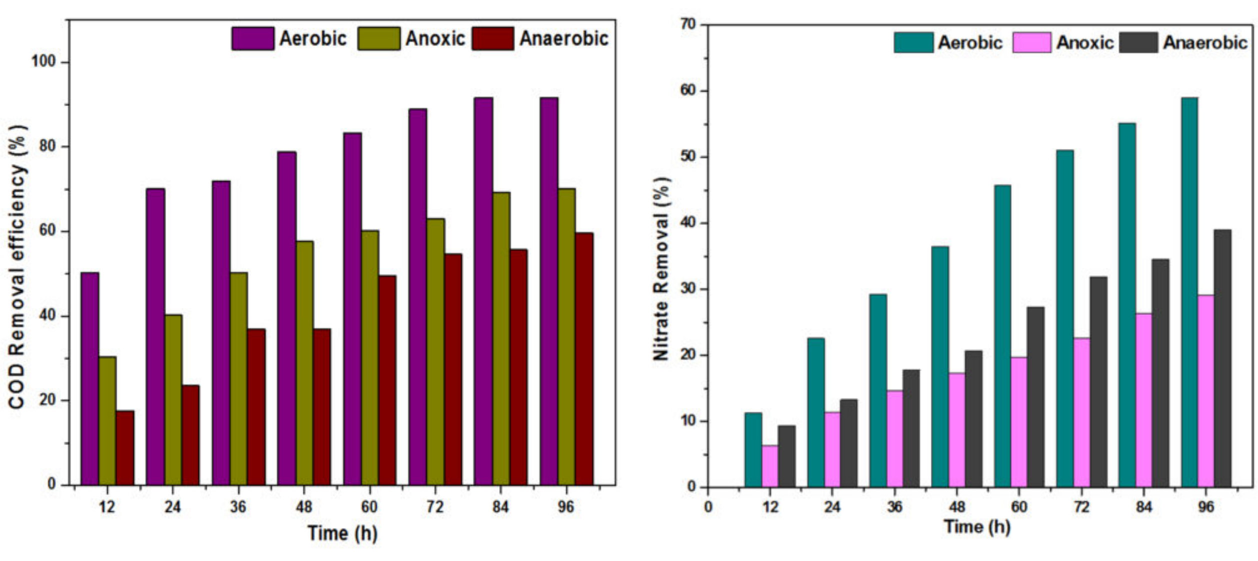

Fig. 2. Profiles of COD and Nitrates removal with function of DO.

Redox microenvironments play a crucial role in the treatment. Oxygen is the one of the best-known TEA under aerobic operation. However, nature of pollutant present in wastewater will govern the TEA. In the absence of oxygen, a wide range of electron acceptors are available in the biological systems, but their function depends on the thermodynamic hierarchy. In the case of azo dye bearing wastewater treatment, reduction reactions are (anoxic/anaerobic microenvironment) more favorable than the oxidation due to the ability of the dye to accept the reducing equivalents, mimicking as TEA.

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