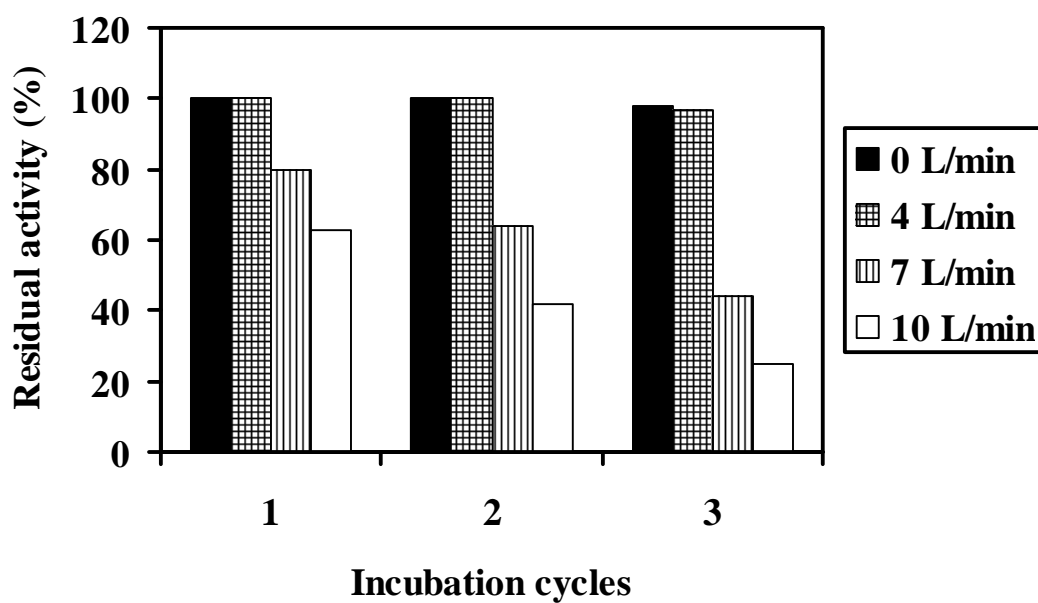


The results showed that dye decolorization using the enzyme entrapped within Cu-alginate bead was the best when air flow rate in the 5 L-airlift bioreactor was adjusted to 4 L/min. Total amount of removed dye at the end of 20 days incubation was as high as 1.8 g. A dramatic loss of efficiency of the immobilized laccase was observed after increasing the air flow rate over 4 L/min, though a high flow rate gave a good circulation of beads in bioreactor.

The residual laccase activity found after dissolution of beads at the end of each cycle was shown in Figure 45. Cu-alginate beads from the flow rate at 0 and 4 L/min could retain 100% relative activity along three incubation cycles. In the higher flow rate system, 7 L/min and 10 L/min, residual activity dropped dramatically along successive incubation cycles. The residual activity at the end of incubation cycle of the best system, 4 L/min, was 100% which 1.3 and 1.6 times higher than those of the 7 L/min-system 10 L/min-system, respectively. These showed that laccase could not retain its activity in the presence of excess oxygen. To our knowledge, this is the first report that the immobilized laccase in Cu-alginate was used to decolorize dye in an airlift bioreactor system. The suitability of the airlift bioreactor for dye decolorization was demonstrated by the amount of oxygen in bioreactor.

Focusing on the potential applications of continuous enzymatic processes, cost reduction of recalcitrant compound treatments is crucial to render these methods competitive with other physical or chemical treatments. From this point of view, this work provides a reasonable basis for application of biotechnology knowledge into dye reduction process. Indeed, the described system is developed with a cheap biocatalyst that is efficient at low concentration and no buffer in the system, thus representing a promising tool to industries plausibly improve this process to be more environmental friendly.



**Figure 45** Percent activity retained by *Ganoderma* sp. KU-Alk4 laccase immobilized in Cu-alginate bead along dye decolorization in 5 L-airlift reactor with different air flow rate.