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DENITRIFICATION WITH INTERMITTENT ORGANIC CARBON SUPPLY UTILIZING ADSORPTION AND DESORPTION CAPABILITY OF GAC

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1. Introduction

In biological denitrification systems dealing with raw water for water supplies and industrial wastewater which contain very minimal amount of organic matter, there is a need to supply an external carbon source to enable more complete NO_3^- removal. Activated carbon has the capability to adsorb and desorb a broad spectrum of organic compounds including some substances which can serve as electron donor for denitrification. In this study, the adsorption and desorption capability of activated carbon was utilized in order to obtain advantages in the operation of denitrification processes utilizing external carbon sources. Injection Mode of organic carbon addition was investigated as a simpler alternative feeding technique to continuous organic carbon supply. In this operation mode, concentrated sucrose solution was injected into the GAC columns at regular frequencies within a day. Utilizing the adsorption and desorption property of activated carbon, it was expected that the supplied sucrose would be stored by the GAC media and would be desorbed gradually to supply the organic source for denitrification during the entire cycle duration.

2. Materials and Methods

The experimental set-up consisted mainly of an upflow fixed bed column (depth: 80 cm, ID: 6 cm, media: GAC Filtrasorb 400, particle size: 0.8-1.4 mm) operated at 25 ^{o}C as shown in Fig. 1. Concentrated organic substrate (sucrose, 95%; peptone, 4.5%; yeast extract, 0.5% COD basis) was injected for 10 min in three sets of independent reactors at frequencies of 1, 2 or 3 times per day respectively as illustrated in Fig. 2. The concentration of the injected organic substrate was varied accordingly to maintain equal average C:N ratio of 1.88 in all cases while the influent NO_3-N level was fixed at 20 mgl^{-1} and Empty Bed Contact Time (EBCT) was controlled at 80 min. NO_3-N feeding was stopped temporarily during the injection period to facilitate maximum sucrose adsorption on the GAC particles. Nutrients were added in proportion to organic carbon supplied. In all cases, routine sampling was conducted midway and towards the end of each cycle.

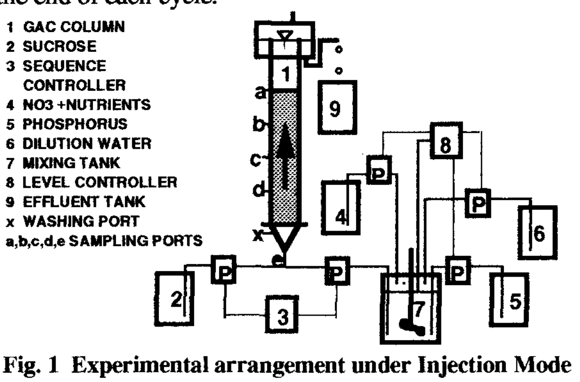

Fig. 1 Experimental arrangement under Injection Mode

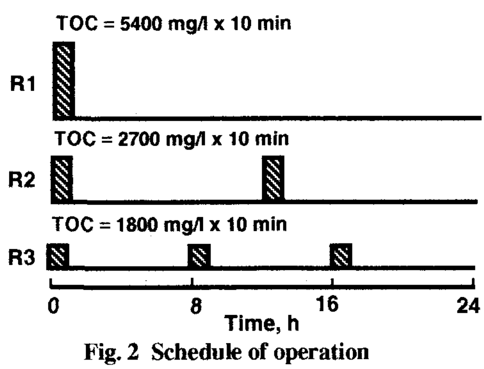

Fig. 2 Schedule of operation

3. Results and Discussion

The change in NO_3+NO_2-N concentration with column depth from the influent entry port to the effluent outlet is presented in Fig. 3. This figure shows that denitrification was possible under Injection Mode and in each case, denitrification was still relatively high even near the end of the cycle when adsorbed sucrose was least available. The overall N removal obtained were 87, 80 and 87% corresponding to cases 1, 2 and 3 respectively which were comparable with the results obtained from a separate study conducted with continuous organic carbon supply under similar operating conditions. In all cases, the whole column contributed to denitrification which implies that under this operation mode, a certain amount of GAC is necessary because of limitations in adsorption and desorption capability. In Fig. 4, prolonged injection interval resulted in gradually declining N removal efficiency with cycle duration because of depletion of available adsorbed sucrose with time but despite this behavior, overall denitrification were still substantially high in all cases. Although shorter cycle duration resulted in more stable reactor performance, the results clearly show that once per day organic substrate injection was sufficient to attain reasonable NO_3^- removal and sustain 80% denitrification all throughout the cycle under these conditions. With the satisfactory denitrification performance of once per day Injection Mode, two supplementary experiments were conducted under this feeding procedure at various influent NO_3-N and EBCT. In all cases, the C:N ratio was maintained at 1.88. The results of these experiments are summarized in Table 1. Although denitrification declined with cycle duration, overall N removal were relatively high even with influent NO_3-N of 80 mgl^{-1}. On the other hand, reduction of EBCT to 40 min still yielded acceptable denitrification however, with further decrease in EBCT, the adsorption rate of GAC was exceeded leading to the loss of organic carbon. Aside from the leakage of organic substrate, the loss of a small fraction of organic matter via sulfate reduction and fermentation during the initial period of the cycle when adsorbed sucrose level was very high pose a potential problem under this operation mode.

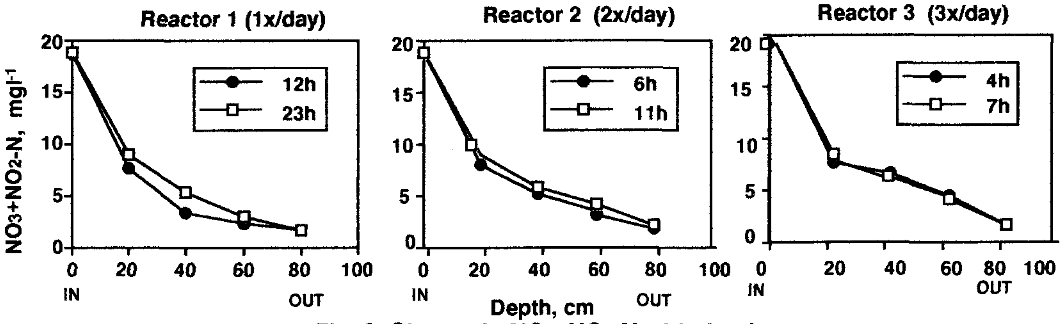

Fig. 3 Change in NO_3+NO_2-N with depth

(C:N = 1.88, EBCT = 80 min, influent NO_3-N = 20 mgl^{-1})

4. Conclusions

With the aid of adsorption and desorption capability of GAC, Injection mode of organic carbon addition was able to achieve satisfactory denitrification for practical application in water treatment. As an alternative to continuous organic carbon supply, this feeding procedure may facilitate reduction in labor and energy costs. With once per day Injection mode, the overall denitrification efficiencies obtained with influent NO_3-N level of 40, 60 and 80 mgl^{-1} were reasonably high for possible utilization of this operation mode to wastewater treatment. However, caution should be exercised with respect to the EBCT to be employed so as not to exceed the maximum adsorption rate of GAC.

*Overall denotes average of the four preceding removal efficiencies.

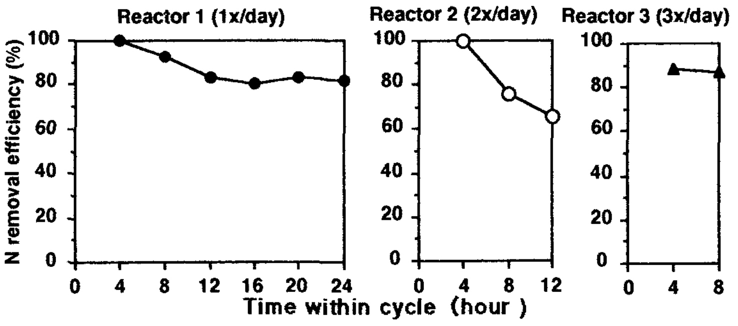

Fig. 4 Change in N removal efficiency within the cycle

(C:N = 1.88, EBCT = 80 min, influent NO_3-N = 20 mgl^{-1})

Table 1 Summary of N removal under various NO_3-N and EBCT

(once per day organic substrate injection, C:N = 1.88)

EBCT, min	NO_3-N, mg/l in influent	N removal Efficiency (%)				
		3h	12h	18h	23h	*Overall
80	10	79	98	100	64	85
	40	99	96	80	60	84
	60	98	98	84	76	89
	80	99	99	79	66	86
80	20	100	93	83	88	91
60		97	93	91	79	90
40		92	67	54	61	68
20		64	11	17	24	29