# Ammonium Removal using Anaerobic Ammonium Oxidation (Anammox Process)

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## Introduction

Nitrogen removal from ammonium-rich wastewater has attracted increased attention due to the serious water pollution consequences such as eutrophication of water bodies (Burkholder et al., 2007; Istvanovics, 2009; Withers et al., 2011). The most widely used ammonium removal technology around the world was the conventional nitrification-denitrification process. However, the application of the conventional process was limited by high operational cost and the external addition of organic matter for the denitrification step (Jetten et al., 1999). Anaerobic ammonium oxidation (anammox) accomplishes direct conversion of ammonium to nitrogen gas. Anaerobic ammonium oxidation (ANAMMOX) is a biological reaction in which the anaerobic ammonium oxidation bacteria (AnAOB) combine nitrite and ammonium to form nitrogen gas using nitrite as electron acceptor under anoxic condition (*Strous et al., 1998; Jetten et al., 1999*). The ANAMMOX process has the following advantages as compared to conventional nitrification–denitrification processes: it does not require the addition of external carbon, less sludge production and low energy consumption (*Tang et al., 2011; van der Star et al., 2007*).

## Methods

1. **Experimental set-up***:* A lab-scale experimental set-up was designed and manufactured. A schematic diagram is shown in Figure-1. The system was fed continuously with synthetic waste water prepared according to (Ni et al., 2010). For the start up of the Fixed Bed Reactor (FBR), granular sludge from Kamen wastewater treatment plant (Figure-2) was used. The characteristics of the sludge are presented in Table-1. To avoid wash out of the sludge, a layer of activated carbon was used. To confirm the presence of the anammox bacteria in the inoculum sludge, fluorescence In-Situ Hybridization (FISH) test was used (Fig.3).
2. The performance of the system was monitored by implementing an intensive chemical analysis program of the influent and effluent of the FBR. The analyses covered ammonia, nitrite, nitrate and chemical oxygen demand.
3. Qualitative and quantitative analysis of the gas produced was carried out (Table 2).
4. Training on full scale Anammox pilot plant in Kamen (Fig. 3)

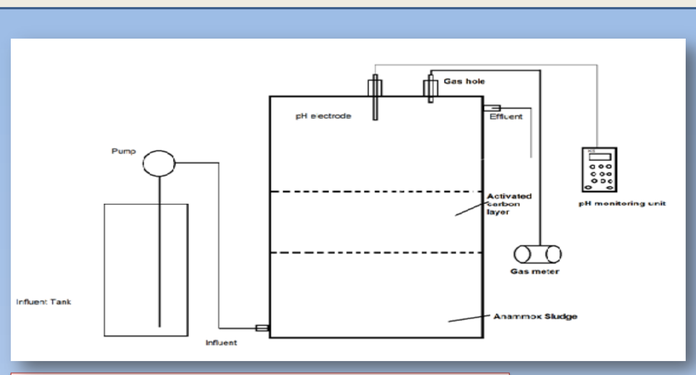


*Figure (1): Experimental set up of the anammox process*

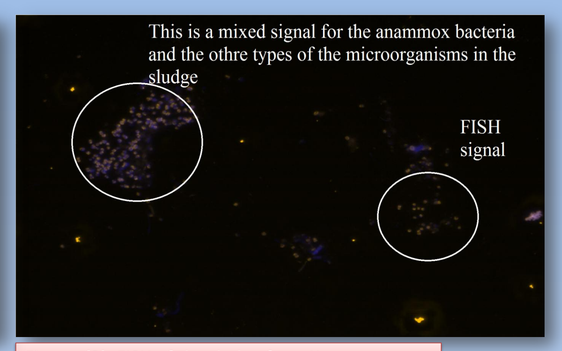


*Figure (2): FISH of the sludge from Kamen*

| Parameter | Unit | Sludge from Kamen |
|---|---|---|
| SV | ml/l | 300 |
| MLSS (105° C) | g/l | 21.9 |
| MLSS (550° C) | g/l | 18.46 |
| VSS/TSS | % | 84.3 |
| SVI | - | 13.6 |

*Table (1): Sludge analysis*

| Parameter | Unit | Fixed Bed Reactor |
|---|---|---|
| $CH_4$ | % | 3.6 |
| $CO_2$ | % | 1.0 |
| $O_2$ | % | 7.2 |
| $H_2S$ | % | 0 |
| Bal | % | 88.2 |

*Table (2): Gas analysis of FBR*

*Figure (3): Wastewater treatment plant in Kamen*

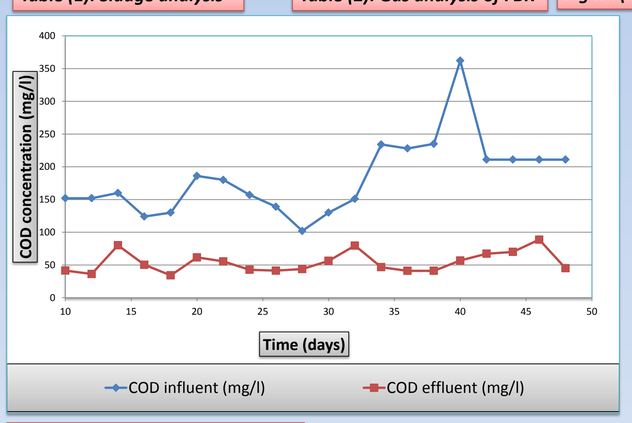


*Figure (5): COD removal efficiency*

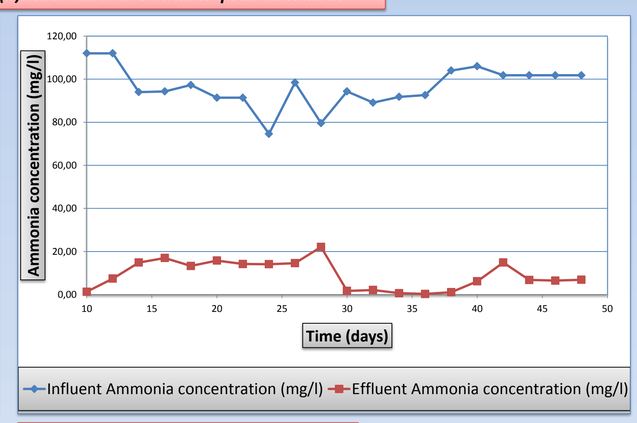


*Figure (4): Ammonia removal efficiency*

## Results

### Anammox process

The FBR was operated for 60 days at ammonia loading rate 0.13 kg/m$^3$/day and hydraulic retention time of 1.36 days. Results of the feed and the treated effluent are summarized in Tables 3 &4.
Available data indicates that the efficiency of the anammox process for ammonia removal reached up to 90.2±7.8% as shown in figure (4). Nitrite, nitrate and COD removal values were 89.0±5.6%, 52.0±11.5 and 68.6±10.9, respectively as shown in (figures 5, 6, and 7 and table 4).

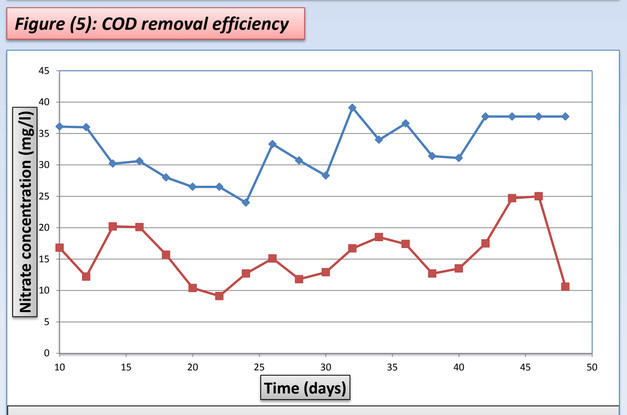


*Figure (7): Nitrate removal efficiency*

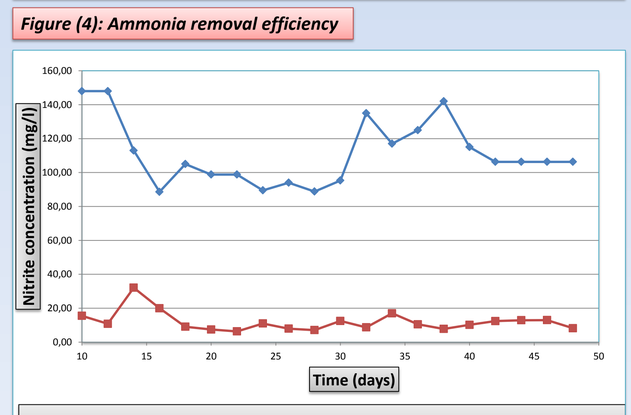


*Figure (6): Nitrite removal efficiency*

| Parameter | Unit | Average | Maximum | Minimum |
|---|---|---|---|---|
| pH | - | 7.8±0.5 | 8.2 | 7.6 |
| Ammonia | mgN/l | 96.5±9.4 | 112 | 74.6 |
| Nitrite | mgN/l | 111.35±19.1 | 148 | 88.8 |
| Nitrate | mgN/l | 32.66±4.5 | 39.1 | 24 |
| COD | mg$O_2$/l | 183.3±58.1 | 362 | 102 |

*Table (3): Chemical analysis of the influent synthetic wastewater*

| Parameter | Average % | Maximum % | Minimum % |
|---|---|---|---|
| Ammonia | 90.2±7.8 | 99.7 | 72.2 |
| Nitrite | 89.0±5.6 | 94.5 | 71.6 |
| Nitrate | 52.0±11.5 | 71.9 | 33.1 |
| COD | 68.6±10.9 | 84.3 | 47.3 |

*Table (4): Average, maximum and minimum removal efficiency of ammonia*

## Conclusions and outlook

The FBR anammox reactor can successfully treat low strength ammonia rich wastewater through the completely autotrophic nitrogen removal process. Using low activity anammox inoculum from full scale pilot plant treating sludge liquor (58.6 % removal efficiency), the inoculated sludge in FBR gave removal efficiency of 90.2%, which was higher than that of the inoculum sludge. FISH analysis confirmed the stable presence of anammox bacteria

## References

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