Analysis of Removal of Nitrate from Wastewater

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Abstract— to reduce environmental damage, nitrate must be removed from the water source. Among the other methods of nitrate removal, biological denitrification is the most versatile option. Fluidized bed biofilm reactor (FBBR) is one of the recent methods that can be used to reject.

Keywords: anoxic; Reject Fluidized Bed Biofilm reactor; FBBR; Methanol; Nitrate

I. Introduction

Excessive use of fertilizers, deep absorption in the fields and significant contribution to the industry have increased the release of nitrogen loads into the waterways (Lucas et al,). Nitrate contamination of water resources is becoming a serious environmental problem worldwide (Killingstad et al., 2; Lee et al., 2; Barisha and winter, 3). Physico-chemical analysis of groundwater was studied in Sambhar Lake City, Rajasthan, India and researchers have found levels of nitrate concentration up to 1,100 mg L-1 (Joshi and Seth, 2009). After a review of the water quality of Upper Lake, Bhopal (India), which provides drinking water to 16 million people, found 150-720 mg l - 1 (Magarde et al., २००) as a nitric acid concentration. In a study conducted for water quality of water sources in Yavatmal District, Maharashtra (India), the ratio of nitrate to 100 mg L - 1 to 500 mg L - 1 was found. Mg districts mg mg mg l-1 allowed levels in districts and two blocks comprising two blocks (Joshi etc.). Similar amounts of nitrate are higher in urban and rural areas in the investigation of groundwater and surface water nitrate content (Garva et al., 2). Nitrate contamination of groundwater sources is becoming a problem in Europe as well as in the US and Canada In many areas, the intensity of nitrate in groundwater has reached critical levels. The US Environmental Protection Agency has exceeded the 10.0 mg nominal limit as NO3 −-N (nitrate nitrogen) or 50 mg L - 1 as NO3− (nitrate). The World Health Organization, the European Economic Community, and some Eastern European countries, e.g. set by Czechoslovakia. Concerns about increasing the concentration of nitrate due to the potential side effects of health are very legal. The toxicity of nitrates for humans has not been clearly established. However, their service may lead to infant methemoglobinemia (blue baby syndrome). Reduction of nitrates to nitrates in saliva can lead to the formation of nitrosamines, called carcinogens (Gomez et al., 2000; Wasik et al., 2001); Geo and so on. 2007; Srinu and Pai, 1) The accumulation of different types of nitrogen in the surface and groundwater can adversely affect the release of dissolved oxygen (DO), disinfection, ammonia poisoning, aquatic organisms, and the presence of nitrate in the drinking water supply. (Hibia et al. 2003)

Thus, to minimize environmental damage, nitrate must be removed from the water source. A survey of the literature found abundant information on technical treatments for nitrate removal from water, including ion exchange, biological denitrification, chemical denitrification, catalytic denitrification, reverse osmosis and electrodialysis (Sahli et al., 2006). Three approaches show some potential for full-scale application: ion exchange, reverse osmosis and biological denitrification.

Nitrate in contaminated water can be removed by ion exchange. Ion exchange is basically a physical / chemical process that requires occasional regeneration to restore the exchange capacity and process efficiency. It is known that periodic regeneration of exhausted resins with sodium chloride (NACL) or sodium bicarbonate (NACHO3) results in expensive regeneration or sea waste at high concentrations of nitrate-N, NACL and NACO3. Ion exchange die by two problems. The first is that a resin of higher selectivity for nitrates does not exist in the groundwater than in ions that normally exist. The second problem involves the ability to regenerate a regeneration solution that does not become a problem in itself.

Reverse osmosis eliminates many ionic species and reduces the mineral content of water. The question with this method is that commonly used screens do not show high selectivity for nitrates. The degree of salt rejection is directly related to the instability of the ion. Therefore, multivalent ions are well removed due to the process.

One of the most promising and versatile approaches to study is biological innovation. This process has been used for years in wastewater treatment. Biological denitrification is extremely selective for nitrate removal. The efficiency of the process is very high and can reach almost 100%, which is unlike any other method available for nitrate reduction. The main disadvantage is the potential bacterial contamination of treated water.

This risk is extremely legal and further treatment and disinfection need to be done to meet the subsequent drinking water levels. Biological innovation can be done in fixed film or suspended growth systems with the help of methanol or some equivalent carbon source. FBBR is a method, which falls into the category of a fixed film type system. This is a recent method and can be used with great benefit for biological conservation

The work presented in this paper relates to the laboratory experimental work. FBBR was established in the lab to study biological innovation. The biofilm carrier media used was sand, which is readily available and economical. This study considers the advantages of FBBR and sand media. FBBR was operated for several days to see the denitrification of artificial seawater for different concentrations of NO3−-N, which is different from 10 mg L - 1. The FBBR showed great potential for rejection.

II. Biological denitrification

Organic nitrification and denitrification are the most economical methods of removing nitrogen from municipal waste water (Li et al., २००२; Kim et al., २००; Ruiz et al., 2006;

Shao et al.,.). The removal of nitrate from waste water is usually achieved by employing a bacterial process of denitrification, in which the nitrate is reduced to neutral nitrogen gas (N2). The process requires the electron (energy) to supply bacteria to the bacteria (Donor et al., २००२; Mora et., २००; Klaas et al., २०० ;; Contras et al., २००;; Viridis et al.,.).). Correct Condition for Denitrification - Absence of Oxygen but Presence of Nitrate, Generally Known as Anosmic. In the biological denitrification process (dissolution), nitrate ions are converted to nitrogen gas by fascial heterotrophic bacteria. It requires anoxic conditions and a source of energy.

Heterotrophic denitrifying bacteria require organic carbon sources for respiration and growth. During the sewage process the carbon source plays an important role in the removal of organic nitrogen and phosphorus (Wu et al., २०१०). Various organic compounds have been used, such as methanol, ethanol, glucose, acetate, aspartate or Formic acid as well as various industrial wastes, including molasses, whey, distillery spillage and sulfite waste. However, the majority of published research on denitrification involves methanol, ethanol and acetic acid. The applicability of methanol in the denitrification process is first determined by economic considerations (Sage et al., 2006). It is a convenient carbon source for high solubility in water, high bioavailability and therefore denitrification. Known stoichiometry (Iwasidis et al. 2005; Fogler et al. 2005). Due to its availability, low cost, favorable sludge production, low volatile organic compound (VOC) emission capacity and no nitrogen and phosphorus, it is the most suitable option.

If methanol is used as a carbon source, the stoichiometric relationships describing the bacterial energy reaction in two steps are written in Equations (1) and (2), giving the complete (dissolution) equation (3): (Metcalf & Eddy, Inc., 2003)

6NO3− + 2CH OH3→ 6NO2− + 2CO2 + 4H O2 (1)

6NO−2 +3CH OH3 → 3N2 +3CO2 +3H O2 + 6OH− (2)

6NO3− +5CH OH3 → 3N2 +5CO2 + 7H O2 +6OH− (3)

Nitrate assimilation is generally expressed by equation (4):

3NO3− +14CH OH3+CO2 + 4H → 3CH NO72 +19H O2 (4)

The cell formula C5H7NO2 suggested by Hoover and Porgess (Metcalf & Eddy, Inc., 2003) was used. The 'overall' (dissimilation + assimilation) process in nitrate-limiting conditions is described by McCarty's equation (5):

NO3− +1.08CH OH3+ H+ → 0.065C H NO5 7 2 +0.467N2 +0.76CO2+ 2.44H O2 (5)

Increasing the equation ()) for nitrate and oxygen, which usually puts the company of nitrate into the feed, gives the empirical relation equation (6) as the basis of weight (Traverso and Cecchi, १ 8 88).

$$M = 2.47(g\ NO_3^{-} - +N)\ 1.53(g\ NO_2^{-} - +N)\ 0.87(g\ O_2)\ (6)$$

The statistics found in the literature differ significantly from the information above. Despite २.4747, the value of multiplier () in the equation is often found to be २.6565. And the indicated work value is 3.0 (g methanol) / (NO3−-N) removed; The coefficients in the equation are 1. In spite of equ ()), and values larger than 0.5-1.5 are also found (Barnes & Anand, 1983).

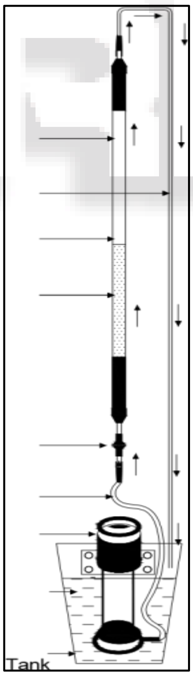
This process of biological innovation depends on the environmental conditions such as oxygen content, temperature and pH (Henin, 2005). Alkalization builds up in rejection reactions and generally raises the pH, rather than being depressed as a reaction to nitrification. Unlike nitrifying animals, there is less concern about the effects of pH on denitrification rates. No significant effect of denitrification rate was reported for pH between 03 to .05 (Metcalf).

III. BIOLOGICAL DENITIFICATION SYSTEM

In an anoxic environment, denitrification of a nitrified fluent can be achieved by providing a zone in which the joints are exposed to large biomass containing heterotrophic microorganisms; And in the presence of a suitable external carbon source. Complete denitrification is possible in the system of growth (fixed film) or suspended growth with the use of methanol or some equivalent carbon source.

IV. FLUIDISED BED BIOFILM REACTOR

The Fluidized Bed Biofilm Reactor (FBBR), the Extract Growth Type reactor (system), is a refurbishment of recent processes in sewage treatment, which uses small, fluorized media to maintain and maintain cell resistance. The main use of this reactor is in the field of biological treatment of sewage. Attention to aerobic and anaerobic FBBRs has been increasing as an effective technology for processing water and sewage (Seok and Komisar, 1,; Raba and Dahab, 4; Choudhary).



Denitrifying reactor
Outlet pipe
Glass tube (0.036 m dia, 1.20m long) Fluid Media
Regulatory Cock Inlet Pipe Pump Artificial Sewage
Fig. 1: Experimental setup of FBBR

Characteristics are - determination of microorganisms on the surface of small-sized particles, which provide a higher surface area for high content of active microorganisms and a reaction with the fluid; Higher flow rates (shorter residence times) that can be achieved, leading to higher mixing (reduced external mass transfer resistance) and greater reduction in tree size; And removing the risk of getting stuck

The basic concept of the process is to transport sewage from a bed packed with particles of sufficient speed to accelerate or accelerate the particles. As wastewater flows upward from the biological bedding, very dense concentrations of animals that grow on the surface of the bed particles use biodegradable waste contaminants in the fluid. Figure 1 is a schematic of the parent unit The process, which flows upstream from the bed to the wastewater, reflects the entire FBBR, thinning the particles into the fluid. Above the bed is a clean water zone in which the particles are separated from the liquid.

From a biological point of view, microorganisms attached to suspended particles may generally include tricking filters and any aerobic, feloactive or aerobic organisms found in suspended growth treatment systems. Depending on the species, the species consumes completely the waste and maintains either the aerobic or aaerobic environment, as well as other factors affecting biological growth.

Fluidized beds combine excellent features of active sludge and trickling filtration into a single process. Offering a fixed film and large surface area, these systems offer the stability and operation of trickling filters, as well as greater operating efficiency of active sludge processing. Importantly, treatments are performed in less space and time, which can be translated into lower costs than traditional treatments. The main reason for this savings in SP

The proportion of active biomass in the reported fluidized bed systems is in the order of 8,000 mg L - 1 to 40,000 mg L - 1, which is usually higher than traditional treatment systems such as full-mixed activated sludge processes in which mixed alcohol suspended solids (MLSS) 3,000 mg L - 1 to 6,000 mg L - 1 or MLSS 6,000 mg L - 1 to 8,000 mg L - 1 (Raba and D) (Obeid, 2004). The reason for this is the available surface area For organic growth in the fluidized bed system, each unit in the reactor unit is much larger than the trailing filter or rotating biological contactors. This area is approximately 2,090 ०m - be, which is higher than the trailing filter (२1.55m २m) or the rotating disc (१ far4mm २m -). Fluid beds have been found to be highly efficient for the biological growth of liquid waste, including the growth of microorganisms attached to carrier particles.

Both aerobic as well as aerobic degradation can be effectively achieved. Traditional suspended increments in capital costs, including land, tanks, pumps, clarifiers and solid separators, cost 1/4 of the cost. Operating costs are slightly lower for the same capacity (Mahajan, 2002) In anaerobic FBBR, biomass concentrations of more than 30,3 mg L - 1 have been reported and the efficiency of extracting organic matter is 5% on loading of kg kg of COD md - 1 on mild waste. Done.

The following is a summary of the benefits of FBBR. First, high biomass concentration can be maintained in the process; Therefore, the system has more metabolic activity than suspended growth system. Second, biofilms with abundant microbial species can no longer have the presence and stability of food chains, prolonged survival of microorganisms, and excessive sludge. Thirdly, the co-existence of aerobic and ox nosic zones in the biomass film may provide the opportunity for simultaneous nitrification and denitrification. Fourth, biofilm processes are less sensitive to toxic conditions and other adverse operational conditions, making them easier to operate and maintain. Finally, the problems caused by weakening of the sludge and sludge mass will not be encountered during operation (Ra and Law, २०१०).

V. MATERIALS AND METHODS

A. FBBR (denitrifying unit)

The experimental set used for this study is shown in Figure 1. Its main body is a 1.22 L reactor made of plasiglass tube (1.236m diameter, 5.5m long), fixed on a steel stand. It is 0.30m. The room is filled with sand of uniform size as a biofilm carrier. At the bottom, a small closed impact tank of 6L capacity is provided with a pump fitted that supplies the reactor to the reactor. An outlet pipe (tube) is joined at the top of the reactor that collects the F in the joints Discharge from reactor and into effective tank again. At the reactor inlet, the regulator is provided to control the flow of the medium in the reactor as well as the fluidization. A good screen is provided at both ends (bottom and top end) of the reactor to prevent sand media from protecting the reactor and evenly distributing the flow to the reactor. The pH, temperature, alkalinity, COD and NO3−N concentration were systematically recorded at the end of each run.

B. Biofilm carrier media

Researchers have tried various materials such as biofilm carrier media e.g. Sand, glass beads, activated carbon, cement balls, plastic, etc. Sand (Ennore sand) was used as the biofilm carrier medium in this study. The characteristics found on the particle size distribution of sand are: effective size (D10) 0.187 mm, uniform coefficient solid (D60 / D10) 0.292, curvature or grading CC ((D30) 2 / (D60 * D10)) 0.035. , And specific gravity 2.56.

C. Feed

In addition to other chemicals, an artificial medium (synthetic wastewater) was created using deionized water. Various different concentrations of NG3-N were added to mg L - 1 as a source of potassium nitrate (KNO3) nitrogen. PO 34− (hence

Na2HPO 4.12H2O and KH2PO4 as a P2 source and medium buffering agent) Determine the mineral constituents required for the growth of bacteria added per liter: ०. mg85 mg feso .7H HHOO, 0.55 mg Na2MOO .2HOO, 0.557 mg MnSO.

To ensure the anoxic state of the reactors, the concentration of oxygen was added below 0.5 mg l - 1 at a ratio of 20 and 0.55 mg l - 1, respectively, of sodium sulfite and cobalt chloride (Raba and Dahab, 2004). Methanol was used as a carbon source. The concentration of NO3.-N and methanol was different at different stages of the study to maintain a moderate (Anthon / NO3 −-N) ratio

D. Operation of the FBBR

Figure 1 shows a schematic diagram of the FBBR that lasted for denitrification for almost a year. The nuclear vaccine was injected into the nuclear wastewater (as a source of bacterial resistance) and operated for 15 days with artificial means. After obtaining the correct results, the reactor was run for 75 days to find the optimal methanol / NO3−-N ratio. For this, each methanol / NO एन-N ratio of 1.2, each of the reactor was run for 15 days.

2.50, 2.75, 3.00 and 3.25. The average NO3−-N removal efficiency obtained was 67.95%, 78.96%, 84.55%, 89.88% and 86.63% for methanol / NO3−-N ratio of 2.25, 2.50, 2.75 00.०० and 25.२ respectively. Therefore a ratio of 3.00 was finalized for the study.

For the experimental work, artificial sediment samples were prepared for different concentrations of NO3.-N, keeping the stable methanol / NO3.-N ratio 3.00. 10.00 mg L - 1, 20.00 mg L - 1, 30.00 mg L - 1, 40.00 mg L - 1, 50.00 mg L - mg l – 1, 90.00 mg l – 1 and 100.00 mg l – 1. For each of these concentrations, the reactor was run for 10 days and various characteristics of influencer and effluent were measured at the end of each run [i.e., hydraulic retention time (HRT) of five minutes, ten minutes, 15 minutes, 20 minutes, 25 minutes and 30 minutes]. The characteristics measured were temperature, pH, alkalinity, COD and NO3− -N.

E. *Analytical Methods.*

Samples were collected from the FBBR at regular intervals and tested for different characteristics. PH was measured by a digital pH meter. Alkalinity was determined by titration method according to APHA (2005). COD was calculated by reflux method according to APHA (2005). NO3 was measured by −-N UV-spectrophotometer (Schemadzu Mech, Model-UV1650).

VI. RESULTS AND DISCUSSION

An experimental denitrification reactor was operated for ten different concentrations and readings were recorded at five minutes, ten minutes, 15 minutes, 20 minutes, 25 minutes, and 30 minutes of HRT. The NO —-N extract was determined on the basis of the results of the medium penetration analysis and the methanol / NO −− NN ratio of the reactor. Average NO3−-N removal efficiency 59.00%, 81.97%,For HRT minutes minutes minutes, 2 minutes, 2 minutes minutes, 2 minutes, 5 minutes minutes and minutes◦ minutes 85 85.44%, .1 87.११%, .2 .2 .5% and .2.88%. The results are shown in Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7 graphs.

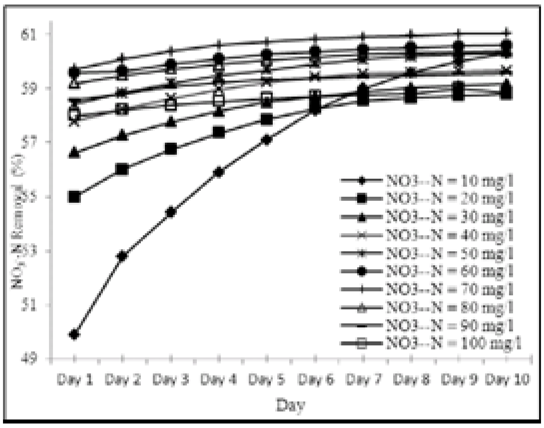


Fig. 2: 3− removal after five minutes (HRT) for different concentrations of NO N3−

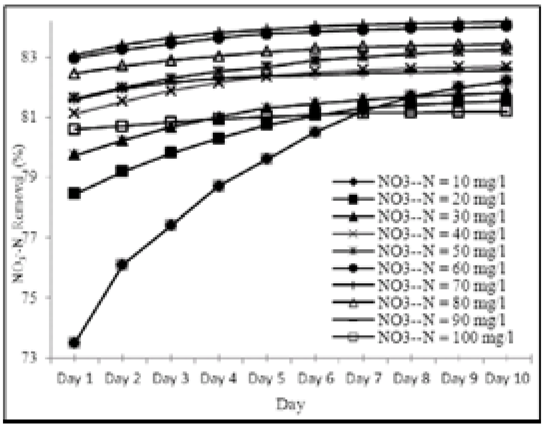


Fig. 3: removal after ten minutes (HRT) for different concentrations of NO N_3−

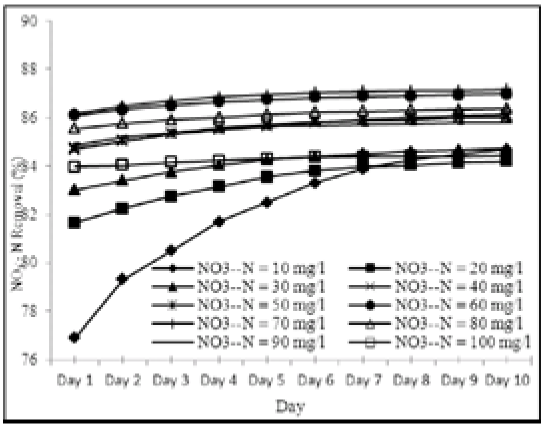


Fig. 4: NO N_3− removal after 15 minutes (HRT) for different concentrations of NO N_3−

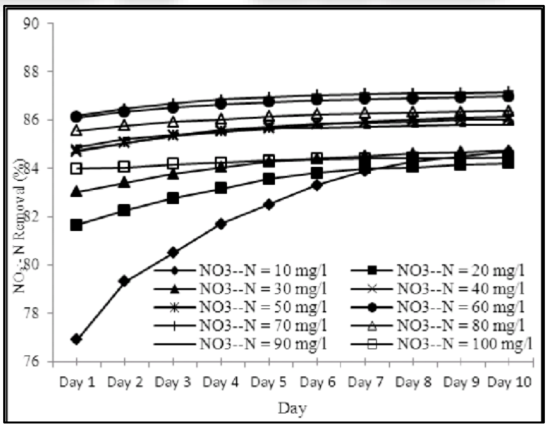


Fig. 5: 3− removal after 20 minutes (HRT) for different concentrations of NO N_3−

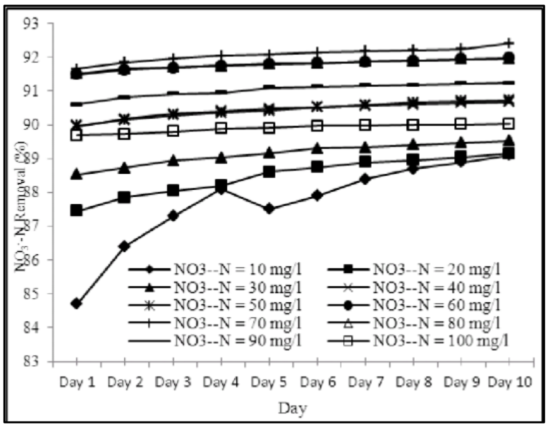


Fig. 6: NO N3− removal after 25 minutes (HRT) for different concentrations of NO N3−

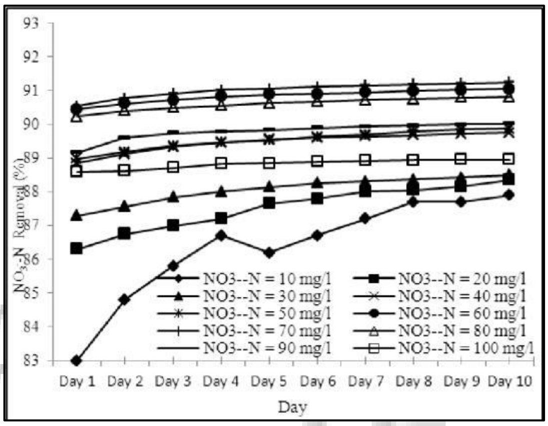


Fig. 7: NO N_3− removal after 30 minutes (HRT) for different concentrations of NO N_3−

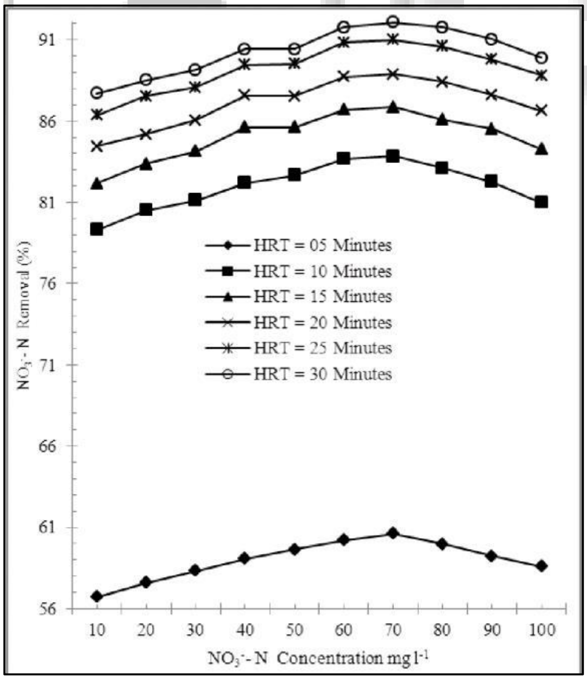


Fig. 8: 3− removal for different concentrations of NO N3− at different

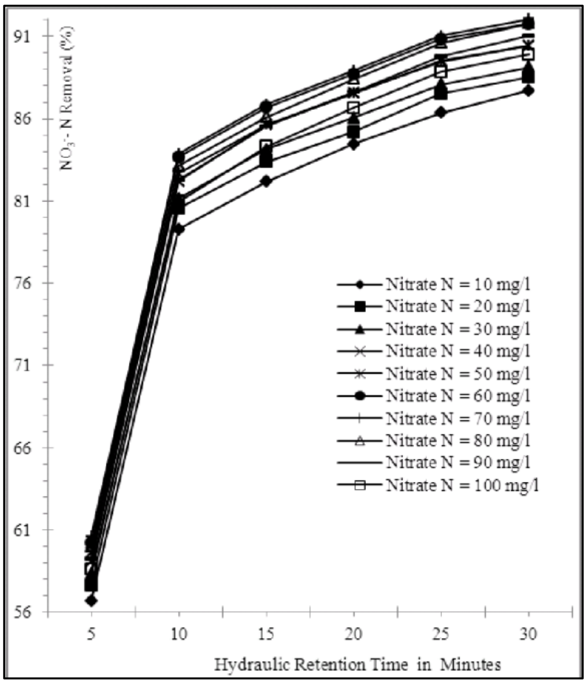


Fig. 9: NO N3− removal for different concentrations of NO N3− at different HRTs

This study showed that the efficiency of NO3−-N removal was in increasing order for increasing concentration of NO3− -N up to 70 mg L-1, after this trend decreased. Average NO3 −-N removal efficiency for a HRT of 30 min for a NO3 एन-N concentration of 10 mg L - 1, 20 mg L - 1, 30 mg L - 1, 40 mg L - 1, 50 mg L - 1 mg. L - 1, 70 mg L - 1 respectively 79 .4.80%, .4.45.5%, .1.44%, .4.40%, .5२.88%, .6 83.55%, .8 83.9 %% but 80० ml Figure 8 shows the graphical representation of the NO3 − N removal% for different HRTs. The figure shows that the concentration of NO3−-N increased in the seawater sample (i.e., from 10.00 mg l - 1 to 70.00 mg l - 1) gradually increasing the NO3−-N removal. But after that there was a slight decrease in NO3. N removal. This may be due to the lower concentration of available biomass compared to the concentration of NO3−-N contained in sewage. A graphical representation of% NO3 − N removal for sewage is shown in Figure 9.

Readings and statistics show that most of the NO3− -N was removed at 10 min HRT. There is a considerable difference between the% of NO3 − N removal at HRT of 10 and 30 min. Thus a HRT of 10 minutes can be considered as the optimal condition. Nitrogen loading rates can vary from 0.48 kg Nm - 3D - 1 to 28.80 kg Nm - 3D - 1. For these nitrogen loading rates, the detected denitrification rates vary from 0.42 kg nm 3d - 1 to 16.87 kg nm - 3d - 1. But the optimum (in terms of optimum NO3− -N removal efficiency), nitrogen loading rate and denitrification rate were 10.08 kg N m 3 D - 1 and 8.45 kg N m - 3. D - 1 res, etc. respectively. (२००)), according to a study examining the technical feasibility of removing biological nitrate in a packed bed reactor using microbial cellulose as a biopolymer carrier, denitrification rate of 70.70 kg NO — N - D - 2 for a loading rate of. Got it-NM - 3D - 1. Biofilm reactors 3.10 to 4.40 kg NO3−NMO 3D - 3 to 10.00–12.00 kg NO3−NMN3D - 3 (Lazarova and Manim, 1994). Raba and Dahab (२००) presented the results of their study in comparison to other studies that reported the use of fluidized bed reactors with methanol as a carbon source (Table 1). The results reported by

Raba and Dahab (2004) were found to be in agreement with the results obtained in this research. In this study, locally available and low-cost materials are used as biofilm carrier media. Considering these and other benefits of FBBR, this would prove to be the best option for B Heterotrophic denitrification increases the ability to release hydroxyl ions and increase the alkalinity. Each mg of nitrate-N reduced to N2 increases the salinity by 3.57 mg CCO3 (van Rijn et al., 2006). In this study, the average yield of alkali of NO3−N-grams extracted was found to be 3.60, which agrees with the values found in the literature. As alkalinity is formed, the pH increases. The pH of the stream was in the range of 6.56 to 7.15 and the accumulated wastewater was in the range of 6.76-7.86

Form of nitrogen	Temperature (°C)	Concentration of nitrogen (mg l^{-1})	Denitrification rate (kg N m^{-3} d^{-1})	References
NO N_3−	18–23	5–100	5.4–20.70	Jeris and Owens (1975)
NO N_3−	-	6.6–30	0.69–3.28	Hermanwicz and Cheng (1990)
NO N_3−	30	15–300	3.23–18.70	Hirata and Meutia (1996)
NO N_3−	20	20	3.5	MacDonald (1990)
NO N_3−	-	676–1500	11.8–17.7	Chen et al. (1996)
NO N_3−	23	1000	12	Rabah and Dahab (2004)
NO N_3−	24.5–40.5	10–100	0.42–16.87 (optimum 8.45)	This study

Source: Courtesy: Rabah and Dahab (2004)

Table 1: Comparison of some studies on denitrification using fluidised bed reactors

The denitrification intensity depends on carbon availability. The carbon to nitrogen ratio in the biological reactor influent should be high enough to denitrify all nitrates arisen in the nitrification process. Komorowska et al. (2006) mentioned in their paper, many researchers' work revealed the g ΔCOD/g ΔN ratio as 3.5–4.5. In the present study, based on all the results, average g of COD consumed per g of NO_3−-N removed is found to be 3.70. This is in confirmation with the results obtained by many researchers.

VII. CONCLUSIONS

The results of the investigation showed that the trend of NO3−-N removal was strongly for up to ten minutes HRT. The average removal rate observed at this HRT was 81.97%. Based on the initial NO3−-N concentration, it was also shown that for initial concentration up to 70 mg L-1, the rate of NO3−-N removal was increasing but for higher concentration, the trend was decreasing slightly. Efficiency can be improved by using a special culture of microbial rejection i The results of this study concluded that biofilm could be used as a carrier media with great advantage to reject FBBR with sand.

This study justifies the recommendation of the FBBR for the refusal by many researchers.

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