Biodenitrification of Wastewater by using F.B.B.R. Technology and by the use of Waste Roofing Tiles

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Abstract

Many types of wastewater treatments are available now a day. Out of these various wastewater treatment methods available Fluidised Bed Biofilm Technology is a very recent innovation in the wastewater treatment. This study mainly focuses on the removal of nitrate from the wastewater i.e. biodenitrification of wastewater. In this study experiments on a Fluidised bed biofilm reactor set up are carried out by the use of waste roofing construction tiles (specially crushed roofing mangalore tiles) as a biofilm carrier media which is used as a substitute over the conventional high cost biofilm carrier media. The FBBR set up is run at different varying hydraulic loading rates and the concentration of the nitrate is measured both at the inlet and outlet end of the set up along with measuring the other chemical characteristics such as COD and pH. Based on these results graphs are drawn and results are compared with other biofilm carrier material. Results states that the use of waste roofing construction tiles can be used with high advantage in the FBBR technology. The maximum average nitrate removal efficiency obtained is 59.02% at an HRT of 5 minutes. Hence use of this technology and biofilm media proves a sustainable option for conventional wastewater treatment.
Keywords: Biodenitrification, Nitrate, Fluidised Bed Biofilm Technology

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I. INTRODUCTION

For the easy and effective growth of the plants nitrates in the form of nitrogen is a very important parameter. All the types of vegetables we eat having a source of nitrates. If nitrates are present in a very small amount, then it does not create any harm to the health of the individual as well as the environment but if it is present in large amount in our body then it may cause a very serious and detrimental effect to our lives as well as our environment.

A wastewater characteristics study was carried out in Sambhar lake city Rajasthan, India in order to check the amount and nature of physical as well as the chemical characteristics of water and in that study the investigators have found the level of nitrate as 1100mg/l, Another case study was carried out to check the water quality of Upper lake Bhopal(India) which supplies drinking water to 16 lacs population in that case study the investigators had found the level of nitrate present in water as 150-720mg/l. In a case study of Maharashtra state district Yavatmal was carried out similarly to check the water quality of Yavatmal district in that case study the researchers had found the level of nitrate as 100-500mg/l. On referring the above case studies, the nitrate limits in many areas of India is greater than the permissible limits of 45mg/l.

Presence of various forms of nitrogen in the subsurface water as well as the surface waters can give rise to very harmful effects such as decreasing the dissolved oxygen (DO) present in receiving water which is very dangerous from the aquatic life health point of view. Nitrate presence also becomes a cause for various public health related problems if it is present in drinking water more than the permissible limits. Hence it is very necessary to remove the excess nitrates from the contaminated water to ensure the environmental standards given by various agencies.

After referring the various literatures regarding the removal of nitrates from water a large information is obtained regarding the various treatment methods to remove nitrate from the wastewater such as Ion exchange, biological denitrification, catalytic denitrification, electrodialysis and reverse osmosis. Out of all these available methods only the biological denitrification shows some large scale application for the removal of nitrates.

Ion exchange method generates a large amount of sludge as well as the periodic regeneration of the ion exchange resin is required which increases the load on the treatment. The process of reverse osmosis is less efficient in removing the nitrate. Out of these three methods available the biological denitrification is found to be very promising and effective in removal of nitrate. The efficiency of this process is very high and can nearly 100% which cannot be matched by any other methods available for the removal of nitrates.

II. BASIC PROCESS

A. Fluidised Bed Biofilm Process

The Fluidised bed is the best reactor which is nothing but the combination of activated sludge process and trickling filter into one process. The fluidized bed biofilm reactor is similar to the fixed bed reactor but in the fluidized bed reactor the space between the biofilm carrier media is expanded by movement or supply of air or water from the bottom of the reactor. Due to which a large biofilm area is made available for the bacterias which indirectly increases the rate of decomposition.

III. REACTOR SET UP

The fluidized bed biofilm reactor set up is as shown in the figure. Its main part consists of reactor tube made up of glass of 1.2-liter capacity which is fixed to the steel stand at the back side. This reactor glass tube is filled with uniform size waste roofing construction tiles (specially mangalore tiles found in the Konkan region) as a biofilm carrier media to a settled depth of 30cm. At the lower end side of the reactor set up, an influent tank of 20liter capacity is provided. To this influent tank a pump is fitted which supplies the influent in the reactor. At the front face of the reactorset up a flow meter is provided to regulate the flow as well as to control the fluidization of the biofilm carrier media in the reactor. At the top of the reactor an outlet pipe is connected which the effluent wastewater from the reactor and discharge again into influent tank. A fine mesh wire filer is provided at the top and at the bottom of the reactor to avoid the escape of the crushed waste roofing tiles from the reactor and also for the uniform distribution of the flow in the reactor.

Fig. 1: FBBR Reactor Set Up

IV. BIOFILM CARRIER MEDIA

In the fluidized bed biofilm reactor set up different types of biofilm carrier media materials have been tried by different researchers such as crushed glass, sand, glass beads, activated carbon, cement ball, fly ash, plastic etc. In this study waste roofing construction tiles (specially mangalore tiles) was used as a biofilm carrier media. The characteristics found after the particle size distribution of waste roofing construction tiles were effective size(D10) 0.082mm, coefficient of uniformity (Cu)3.989, Coefficient of curvature or gradation (Cc) as 0.066 and specific gravity 2.43. The fluidized bed biofilm reactor set up is as shown in the figure. Its main part consists of reactor tube made up of glass of 1.2-liter capacity which is fixed to the steel stand at the back side. This reactor glass tube is filled with uniform size waste roofing construction tiles (specially mangalore tiles found in the Konkan region) as a biofilm carrier media to a settled depth of 30cm. At the lower end side of the reactor set up, an influent tank of 20liter capacity is provided. To this influent tank a pump is fitted which supplies the influent in the reactor. At the front face of the reactorset up a flow meter is provided to regulate the flow as well as to control the fluidization of the biofilm carrier media in the reactor. At the top of the reactor an outlet pipe is connected which the effluent wastewater from the reactor and discharge again into influent tank. A fine mesh wire filer is provided at the top and at the bottom of the reactor to avoid the escape of the crushed waste roofing tiles from the reactor and also for the uniform distribution of the flow in the reactor.

V. Feed

A synthetic medium (synthetic wastewater) was prepare using deionized water in addition to the other chemicals. Potassium nitrate (KNO3) was added as the nitrogen source at different varying concentrations of NO3-N in mg/l. Na2HPO4.12H2O and KH2PO4 both as a P source and a medium buffering agent. Trace mineral constituents essential for bacterial growth added per liter of water were 0.85mg FeSO4.7H2O, 0.25mg Na2MoO4.2H2O, 0.157 mg MnSO4.7H2O and 33mg of NaHCO3. Sodium sulphite and Cobalt chloride were added at concentrations of 20 and 0.55mg/l respectively, to reduce the oxygen concentration to below 0.5mg/l to ensure anoxic conditions in the reactors. The methanol was used as a carbon source. The concentration NO3-N and methanol in the medium was varied at different stages of the study to maintain the methanol/NO3-N ratio.

VI. Operation of F.B.B.R.

For experimental work the synthetic wastewater samples were prepared for varying concentrations of nitrates of 10mg/l, 20 mg/l, 30 mg/l, 40mg/l, 50 mg/l, 60 mg/l, 70 mg/l, 80 mg/l, 90 mg/l, 100mg/l. For each of these concentrations separately, the reactor was run for 10 days and various concentrations of influent and effluent were measured at the end of each run. i.e. Hydraulic Retention Time (HRT) of 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes and 30 minutes. The characteristics measured were pH, COD and Nitrate. The pH was measured by pH meter. COD was measured by reflux method and nitrates was measured by UV- spectrophotometer.

VII. Results and Discussions

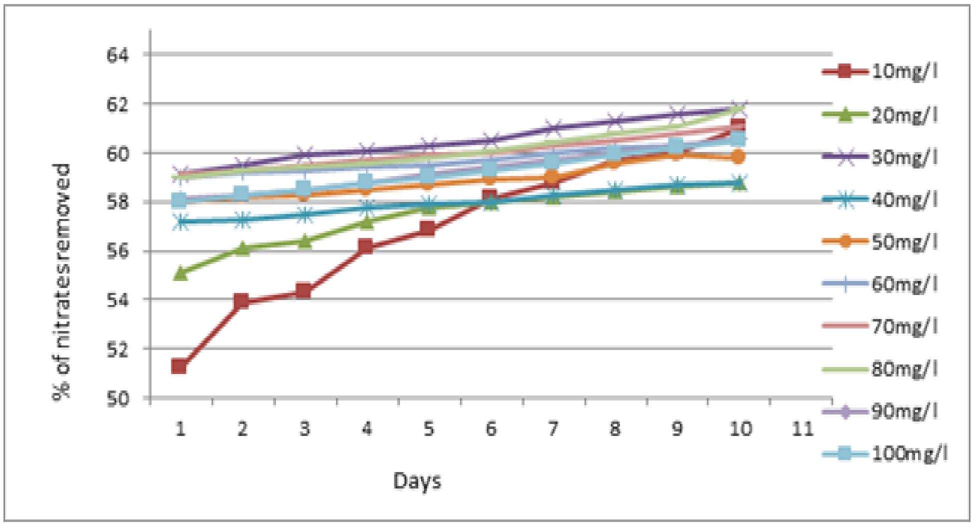

Fig. 2: Graph of Percentage of Nitrate Removal at HRT of 5 Minutes

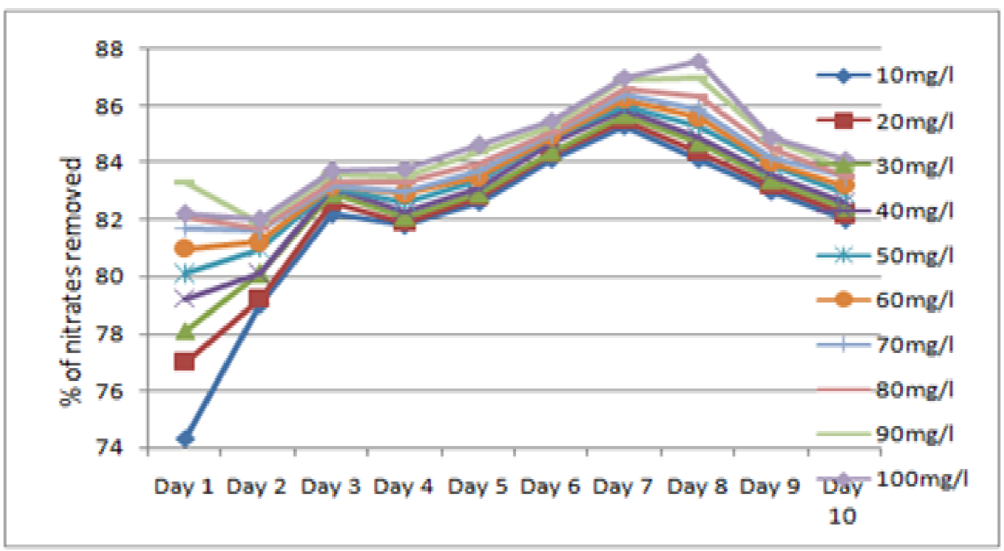

Fig. 3: Graph of Percentage of Nitrate Removal at HRT of 10 Minutes

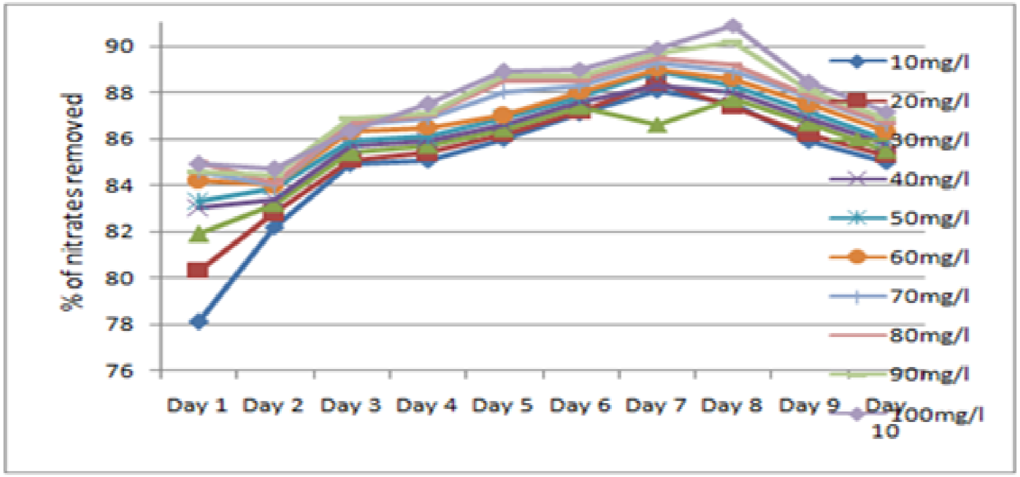

Fig. 4: Graph of Percentage of Nitrate Removal at HRT of 15 Minutes

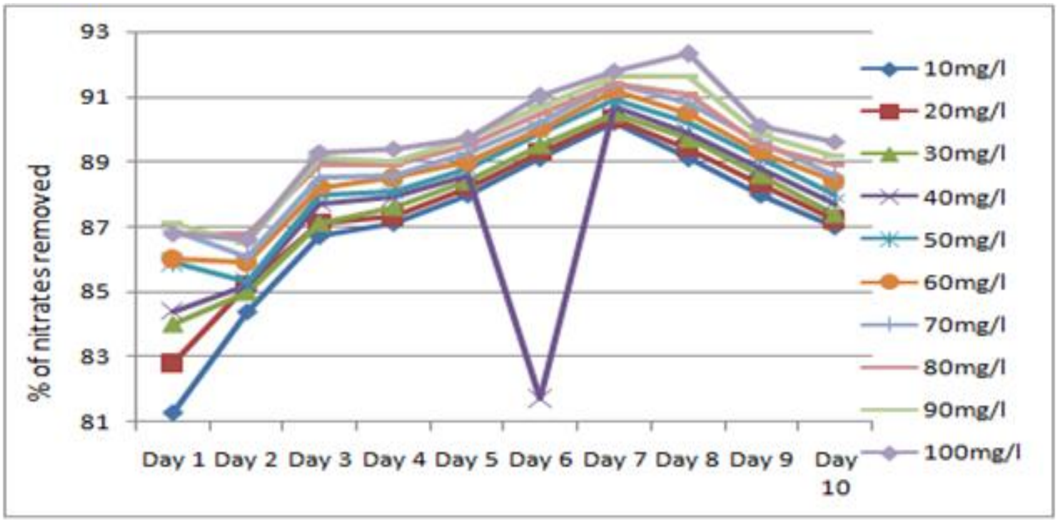

Fig. 5: Graph of Percentage of Nitrate Removal at HRT of 20 Minutes

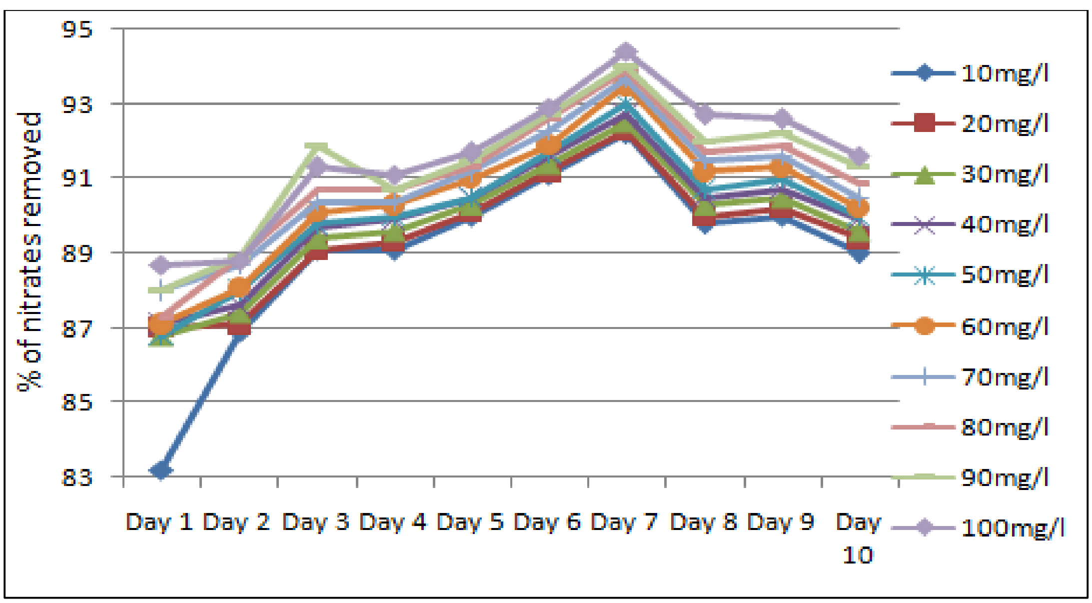

Fig. 6: Graph Of Percentage Of Nitrate Removal At HRT Of 25 Minutes

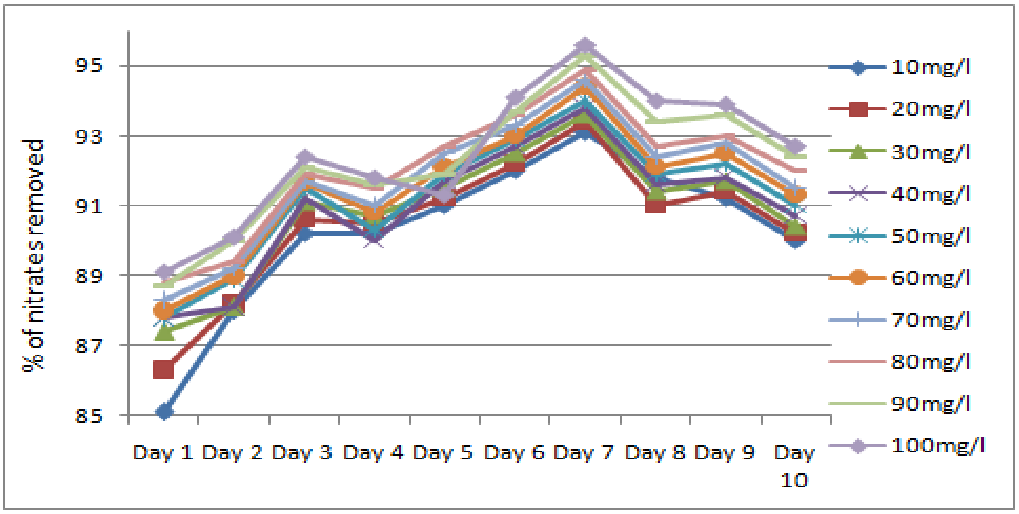

Fig. 7: Graph Of Percentage Of Nitrate Removal At HRT Of 30 Minutes

Effects on Nitrate Removal Rate; Nitrates reading at different HRT and at different concentrations from 10 mg/l to 100mg/l are taken during the running period of the reactor. Respective readings are plotted on graph. From the graph average nitrate removal efficiency obtained was 59.02% at an HRT of 5 minutes, at an HRT of 10 minutes' average nitrate removal efficiency obtained was 83.47%, at an HRT of 15 minutes' average nitrate removal efficiency obtained was 86.50%, at an HRT of 20 minutes' average nitrate removal efficiency obtained was 88.40%, at an HRT of 25 minutes' average nitrate removal efficiency obtained was 90.37%, at an HRT of 30 minutes' average nitrate removal efficiency obtained was 91.38%. Thus, maximum nitrate removal rate obtained at an HRT of 30 minutes. Hence FBBR proves very high efficiency in removing the nitrates from the wastewater.

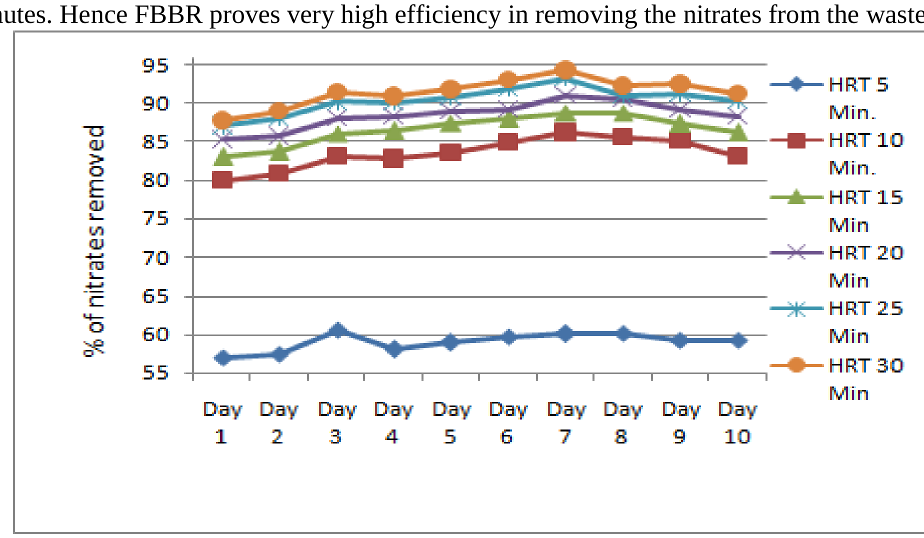

Fig. 8: Graph of Average Percentage of Nitrate Removal at Different HRT

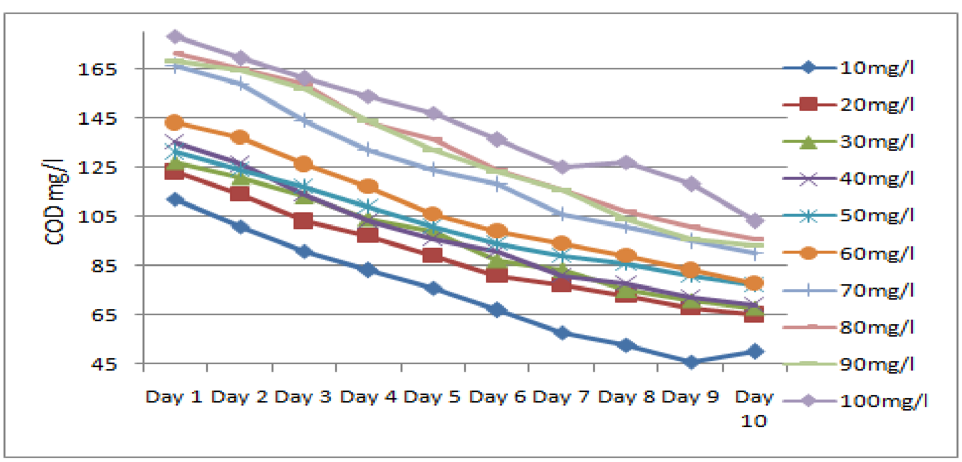

Fig. 9: Graph Of Removal Of COD Before Starting The Reactor

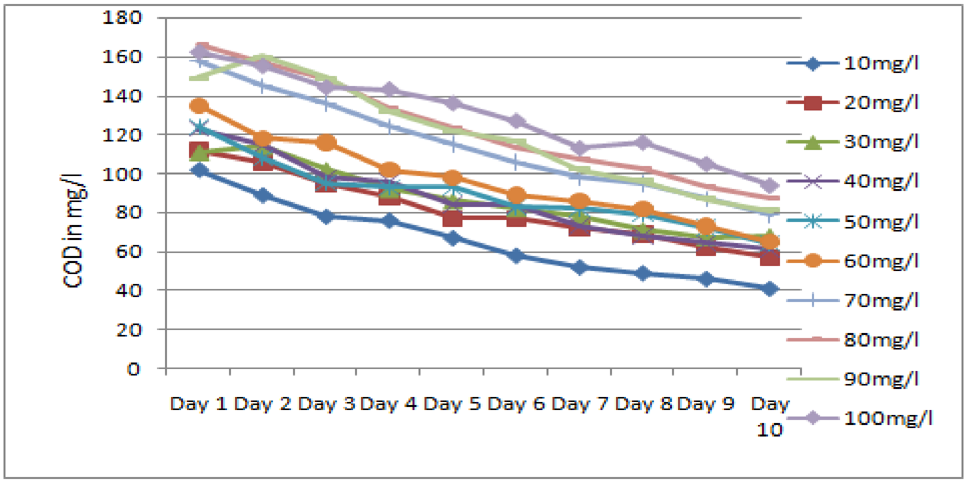

Fig. 10: Graph Of Removal Of COD At The End Of Fluidization

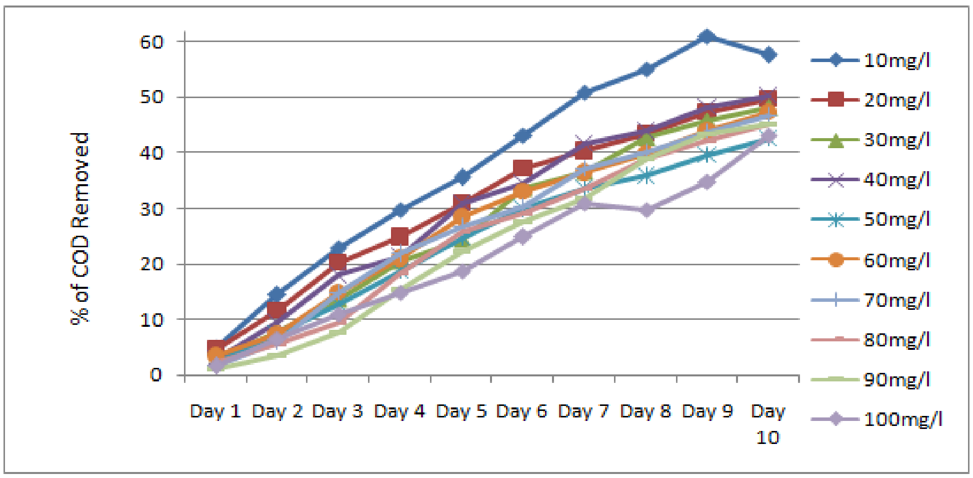

Fig. 11: Graph Percentage of COD Removed at Different Concentrations of Nitrates at the End of Fluidization.

Effects on COD Removal Rate; Readings of COD are taken during the entire running period of the reactor . COD is measured at both the conditions before starting up the FBBR set up and at the end of fluidization. Respective graphs are plotted on axis. By referring the graph maximum COD removed during the running period of an FBBR is 61.7% at an concentration of 10 mg/l and minimum percentage of COD removed is 1.18% at an concentration of 90mg/l. For the increase in concentration there is decrese in the COD removal rate.

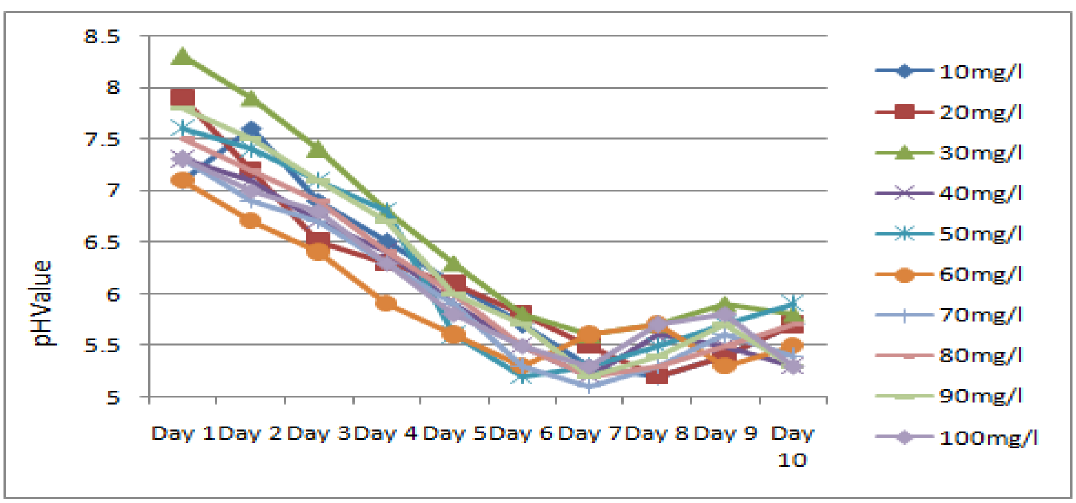

Fig. 12: Graph Of Readings of Ph Before Starting the Reactor

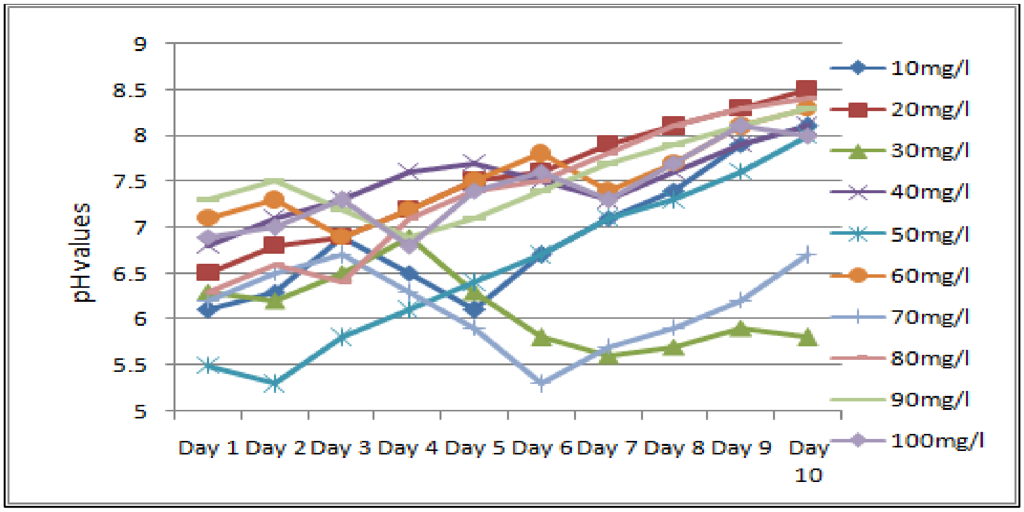

Fig.13: Graph of Readings of Ph at the end of Fluidization

Effects on pH Rate; FBBR founds to be quite effective in maintaining the pH. The pH ranges during the fluidization operation between 5.3 to8.3. The maximum pH obtained during the experiment is 8.3 and the minimum pH obtained during the experiment is 5.3. Readings are taken at the conditions before starring of the reactor and at the end of fluidization. The respective graphs are plotted based on the readings. The trend of the graph is towards the decrease in pH but slightly increases afterwards which means that alkalinity is produced during the denitrification. This pH range is suitable for the growth of the bacteria.

VIII. CONCLUSION

After carrying out the experimental work on the fluidized bed biofilm set up following conclusions are made
FBBR bears very high potential for removal of nitrates from the wastewater nearly up to 100% as compared to the other methods of nitrate removal. Results states that the use of waste roofing construction tiles as a biofilm carrier media can be use in the FBBR technology with a very high advantage. The average nitrate removal efficiency obtained was 91.38% at an HRT of 30 minutes. The minimum average nitrate removal efficiency obtained is 59.02% at an HRT of 5 minutes. FBBR proves to be a sustainable option for conventional wastewater treatment.

Table - 1

Form of Nitrogen	*Used Biofilm carrier media*	*Conc. Of nitrates in mg/l*	*Optimum nitrate removal efficiency*	*HRT in Minutes*	*Maximum Nitrate Removal Efficiency*
Nitrate	*Waste roofing construction tiles*	*10-100*	*94.4*	*20*	*95.6%*
Nitrate	*Fly ash*	*10-100*	*91*	*10*	*95.98%*
Nitrate	*Fine glass granules*	*10-100*	*86.3*	*10*	*90.09%*

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REFERENCES

[1] S.P. Burghate and W. N. Ingole “Efficiency Evaluation of FBBR for denitrification using fly ash” Journal of Environmental Science, Comupter science and Engineering and Technology
[2] S.P. Burghate and W. N. Ingole “fluidized bed biofilm reactor” International Journal of Research in Environmental Science and Technoology2013:3(4):145-155 ISSN 2249-9695.
[3] R.R. Souza. I.T.L.Bresolin. T.L.Bioni M.L.Gimenes and B.P.Dias-Filho “ The Performance of a Three- Phase Fluidized Bed Reactor in the Treatment of Wastewater with High Organic load” Brazilian Journal of Chemical Engineering, Vol.21, pp229-227, April- June 2004, ISSN 0104-6632
[4] K.S.K.Rao Patnaik amd K. Sriharsha “ Fluidization Principles for Three Phase Fluidized Bed Bioreactor” International Journal of Chemical Engineering and Applications. Vol.1, No.03, October 2010, ISSN 2010-0221.
[5] Wlodzimierz Sokol “Optimal Aerations in the Inverse Fluidized Bed Biofilm Reactor when used in the treatment of Industrial wastewaters of various strength” Advances in Chemical Engineering and Science, 2012,2,384-391.
[6] M.A. Stylianou, V.J. Inglezakis and M.Loizidou “ Experimental studies on Fluidized and Fixed Bed Reactors for the removal of Heavy Metals from aqueous solutions” University of Cyprus, Department of Civil and Environmental Engineering, International Water Research Centre, Nicosia, Cyprusm Young, The Technical Writers Handbook Mill Valley, CA: University Science, 1989.
[7] Metcalf and Eddy, Inc., Wastewater Engineering: Treatment and Reuse, Fourth Edition, Tata McGraw Hill Company Limited, New Delhi, 613, 1819(2003).
[8] Mahajan S.P., Pollution Control in Process Industries, Fifteenth Edition, McGraw Hill Company Limited, New Delhi, 75-76, (2003).