

Table 3: Characteristics of synthetic wastewater

Parameters	Quantity (mg/L)
pH	7.79
Temperature	32.6
DO	3.5
BOD	80
COD	124
COD/ NO ₃ -N	2.52
NO ₃ -N	49.16
NO ₂ -N	Not detected
PO ₄ -P	10.98

The level of nitrate will be continuously analyzed for about 4 weeks. The analysis showed that the nitrate content was almost similar to the value required. The COD/ NO₃-N is low, but it will be enhanced by the addition of the external carbon source.

Dissolved oxygen is within the required limit, which can be from 0 to 4.5 mg/L. pH and temperature is found to be within the range and suitable for denitrification.

COD/ NO₃-N values for the three media were calculated after the completion of the experiment. The value obtained for wood, paddy straw and newspaper is 0.369, 1.661 and 18.135, respectively. This shows that there is a high enrichment of COD due to the addition of newspaper as external carbon source or may be due to the low value of nitrate. Similarly BOD was also found to increase, with a value of 270, 250 and 180 mg/L respectively.

3.2 Optical Density and Plate Count

The value of optical density for the inoculum was found to be 1.157. It shows the absorbance of the culture, and hence more the value, the growth will be more. There is no standard value for optical density and it varies depending on the species and the value obtained here showed a highly turbid culture. From the plate count a high value of growth of 70 CFU/mL was obtained. Optical density and cell count is proportional to each other.

3.3 Characterisation of Porous Material

The characteristic study of the three materials was done to study the subjective measure of degradation of the media due to denitrification. All the media were filled to a compressed height of 20 cm. Changes in height and mass have been observed and recorded during the course of this study. Porosity of the reactor media was determined before the denitrification test.

Table 4: Characteristics of media

Characteristics	Wood		Straw		Newspaper	
	initial	final	initial	final	initial	final
Mass (g)	296	820	72	525	246	1430
Height (cm)	20	26	20	28	20	30
C/N	7.33	4.31	8.44	1.73	6.79	11.83
Porosity	0.3		0.4		0.5	

The mass of all the three media was found to increase, with straw and newspaper by a value of more than 80%. The increase is due to the absorbance of water by the media and

shows the degradation of the media. The initial height at which the media was filled was 20 cm. On filling 2L water the height of media was increased and this was used for the calculation of porosity. Newspaper was found to have maximum porosity among the three.

C/N ratio calculation was calculated by analysing total carbon and total nitrogen. Except for newspaper, C/N ratio was found to decrease due to the enrichment of nutrients. Low C/N favors biodegradation and the least value was obtained for paddy straw. This shows that irrespective of the denitrification rate, the media degrades.

Visual observations of the media degradation were also noticed. Of the three media, paddy straw exhibited more signs of physical change. The spent straw was darker in colour. Fungal growth was noticed in both the organic media (wood and paddy straw). Newspaper had the least degradation along with providing the best media for denitrification.

3.4 Denitrification of Synthetic Wastewater

In order to study denitrification efficiency of the three media, the reactors have been filled with 2L synthetic wastewater as composed using Table 1 and 2. 20 mL of the acclimatized sample is also added to the reactor for the microbial action. The following figures show the various nitrate concentration obtained in a time period of 4 weeks. For most of the experimental period, the nitrate concentration in the effluent from reactor with newspaper was found to be lower than the other two media.

At the beginning of the experiment, the nitrate content in the reactor with newspaper was found to decrease. But a sudden increase in the nitrate content was noticed in the other two reactors. Within 5 days, the nitrate content started to decrease in the reactor with straw, while in the reactor with wood, decrease of nitrate was after a further increase. The nitrate content was observed to be double than the straw. Once it started to decrease, it has been a gradual process in both the reactors. All this while nitrate content in the reactor with newspaper was gradually decreasing with a slight increase after 17 days. The value was well below the initial nitrate concentration.

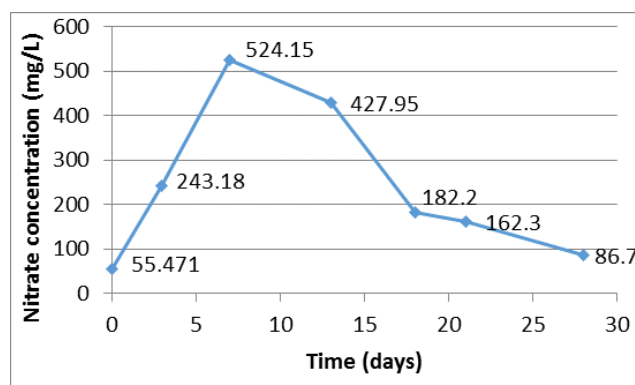


Figure 3: Nitrate concentration with wood as media

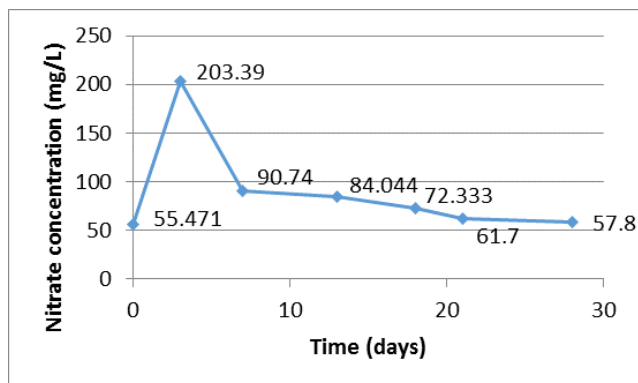


Figure 4: Nitrate concentration with paddy straw as media

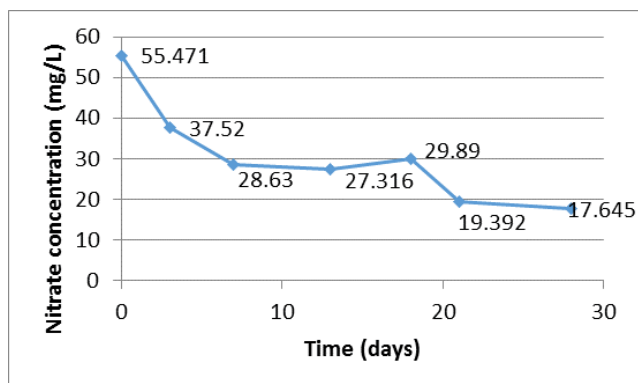


Figure 5: Nitrate concentration with newspaper as media

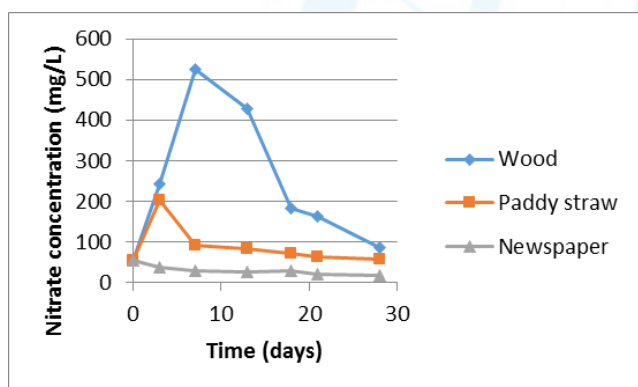


Figure 6: Comparison curve for the three media

4. Conclusion

It has already been established that biological methods of denitrification is the best compared to physical and chemical methods. The denitrification capacity among the three media was found to be maximum for newspaper. It was found to provide a good bacterial support without getting biologically degraded. Moreover the effluent from this reactor does not require any further treatment. Hence newspaper can be effectively used for denitrification process of short duration and is a good method of reuse.

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References

- [1] Barrett M., Kilroy K, Murphy S., Jahangir M.M.R., Richards K.G, Dubber D., Keegan M., Gill L.W., O'Flaherty V., (2012), "Understanding microbial denitrification and pathogen transport in effluent and soils".
- [2] Christianson, Laura Elizabeth, (2011), "Design and performance of denitrification bioreactors for agricultural drainage", Graduate Thesis and Dissertations.
- [3] Gomez M. A., Hontoria E., Gonzales-Lopez. J, (2002), "Effect of dissolved oxygen concentration on nitrate removal from groundwater using a denitrifying submerged filter", Journal of Hazardous Materials B90, 267-278.
- [4] Jalal K.C.A., MD. Zahangir Alam, Matin W.A., Kamaruzzaman B.Y., Akbar. and Toffazel Hossain, (2011), "Removal of Nitrate and Phosphate from Municipal Wastewater sludge by *Chlorella vulgaris*, *Spirulina platensis* and *Scenedesmus quadricauda*", IIUM Engineering Journal, Vol. 12, No. 4, 125-132.
- [5] Jyothi J. Madam, (2008), "Biological Denitrification – A solution to eutrophication", Thesis Report, Department of Civil Engineering, College of Engineering, Trivandrum
- [6] Michal Volokita, Shimshon Belkin, Aharon Abeliovich, M. Ines M. Soares, (1996), "Biological Denitrification of Drinking water using newspaper", Water Resources Journal, Vol.30, No. 4, 965-971.
- [7] Paolo De Filippis, Luca Di Palma, Marco Scarsella, Nicola Verdone, (2013) "Biological Denitrification of High-Nitrate Wastewaters: a Comparison between Three Electron Donors", A publication of Italian Association of Chemical Engineering, Vol 32, 319-324.
- [8] Srinu Naik S. & Pydi Shetty Y., (2011), "Effect of carbon sources on biological denitrification of wastewater by immobilized *Pseudomonas stutzeri* bacteria in a Fluidized Bed Bio Reactor (FBBR)", 1st International Conference on Chemical Engineering and Applications IPC-BEE, Volume 23
- [9] Susumu Hashimoto, Kenji Furukawa, and Masahiko Shioyama, (1987) "Autotrophic Denitrification using Elemental Sulfur", Journal of Fermentation Technology, Vol. 65, No. 6, 683-692.
- [10] Willie Jones B. Saliling, Philip W. Westerman, Thomas M. Losordo, (2007) "Wood chips and wheat straw as alternative biofilter media for denitrification reactors treating aquaculture and other wastewaters with high nitrate concentrations", Aquacultural Engineering 37 (2007), 222-233

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