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Denitrification of steel plant effluent using immobilized Tamarindus indica seeds

KEYWORDS: toxic effluents, nitrates, immobilization, economical, tamarind seeds, modeling equation

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ABSTRACT *The rise of industrialization has rapidly leaded to destruction of natural sources, which directly or indirectly affects the human and animal life. The releases of toxic effluents from these industries ultimately end up polluting the air, soil and the water surrounding the region. Toxic compounds include various heavy metals and elements like fluorides, phenols, nitrates, chlorides, calcium, magnesium salts, etc. These compounds cause a great loss to both flora and fauna. The whole life cycle is disturbed due to these pollutants. This paper explains the importance of treating nitrates and the simple and economical method of treating nitrates with immobilization of tamarind seeds and explains the conversion of nitrates by modeling an equation and fitting it into the best curve.*

INTRODUCTION:

The movement of Tamarind to Asia must have taken place in the first millennium BC. Cultivation of Tamarind in Egypt by 400 BC has been documented and it was mentioned in the Indian Brahmasamhita Scriptures between 1200and 200 BC. About 370-287 BC, Theophrastus wrote on plants and two descriptions refer to Tamarind, his sources were probably from East Africa.In India, Tamarind is known by a wide variety of vernacular names: Tetuli (Assamese); Amli, Nuli, Textili Tentul (Bengali); Amali, Ambali (Gujarati); Ambli, Amli, Imli, (Hindi); Puli (Malayalam); Amli, Chinch, Chitz (Marathi); Koya, Tentuli (Oriya); Imli (Punjabi); Chinta (Telugu).This tree produces certain brown colored pods which are pulpy and hard inside with seeds. When these fruits mature they have hard, glossy round shaped seeds enclosed each in a parchment. A mature tree produces around 150kgs to 225 kgs of fruits per year. Out of this the 25 to 30% will be the pulp, 11 to 20% will be the fiber and the shell and the remaining 30 to 40% will be the seeds. Thus, large quantities of tamarind seeds are available as agro-by-product or waste[1]. And this paper explains the application of these seeds by immobilization technique (sodium alginate beads) to reduce the toxic levels of nitrates in the effluent[2].

Taxonomical classification:

- Kingdom: Plantae
- Phylum: Spermatophyte
- Class: Angiosperm
- Sub class : Dicotyledone
- Family : Leguminosae
- Subfamily: Caesalpiniaceae
- Genus: *Tamarindus*
- Species: *indica*

Fig1:Tamarindus indica seeds

Immobilization:

There are various toxic compounds that pollute the water due to the industrialization like cadmium, nitrates, mercury, phenols, chromium, nickel, lead, etc. Hence, in order to treat such toxic pollutants biological methods are the most eco friendly techniques. The technique that we have chosen to entrap the nitrates using tamarind seeds which is very simple, cheaper and eco friendly. [3]

Immobilized enzymes are used in organic syntheses to fully exploit the technical and economical advantages of biocatalysts based on isolated enzymes. Immobilization enables the separation of the enzyme catalyst easily from the reaction mixture, and can lower the costs of enzymes dramatically. This is true for immobilized enzyme preparations that provide a well balanced overall performance, based on reasonable immobilization yields, low mass transfer limitations, and high operational stability [4,5,6]. There are many methods available for immobilization which span from binding on prefabricated carrier materials to incorporation into in situ prepared carriers. Operative binding forces vary between weak multiple adsorptive interactions and single attachments through strong covalent binding [7]. Which of the methods is the most appropriate is usually a matter of the desired applications.

Materials Required:

- Sodium alginate
- Calcium chloride
- Tamarind seeds powder
- Distilled water
- Beakers
- Syringe
- Glass columns

Method:

Before treating the effluent, it has undergone the stage of pretreatment. This step involves the removal of solids in undissolved state and other particles. The principle behind this method is the flocculation and coagulation to treat the effluent initially. We have used alum, polyvinyl alcohol and dolomite to pre treat the effluent [8].

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After this step, the sodium alginate beads are prepared as follows:
1gm of sodium alginate was dissolved in 25ml of distilled water.

5gms of tamarind powder was dissolved in 25ml of distilled water.

1.5gms of $cacl_2$ in 100ml of distilled water.

After, making the above solutions ready, take the sodium alginate solution and the tamarind solution in a beaker, mix it well.

Then take the $CaCl_2$ solution in another beaker. And, with the help of a syringe, drop the sodium alginate mixed solution slowly drop wise into $cacl_2$.

Hence, finally this will result in sodium alginate entrapped tamarind seeds powder beads. These beads are left undisturbed in the solution for 2 to 3 days to attain hardening. These beads are transferred into transparent columns to a length of 10cm.

Both the pretreated sample and the untreated effluent were taken in different columns to compare the difference in denitrification. The sample was directly poured into the beads in column and readings were observed for every 24hrs.

Estimation of nitrates :
- 10 ml of sample(effluent) is to be taken
- To the sample 1ml of NaOH is added.
- Add 1ml of methyl anthranalite to the above and shake it for 5min.
- Then add 1ml of salfanalic acid.
- Add 2ml of 1N Hcl to the above.
- Finally add 10 ml of distilled water to it.
- Take readings of absorption under UV spectrophotometer at 490nm.

The readings taken by the above method indicate the amount of nitrates in the sample. Hence, amount of nitrates reduced by the plants were studied with the estimation method both before and after pretreatment. The readings were taken till the minimum amounts of nitrates were observed [4].

Fig2: Columns with beads and effluent

Results and discussions:
After 24hrs the nitrates level was the same when readings were taken the second day. Hence ,this indicated that this was the maximum reduction of nitrates using immobilization technique.

After 24hrs the nitrates level was the same when readings were taken the second day. Hence, this indicated that this was the maximum reduction of nitrates in Packed column of immobilized sodium alginate beads. For every 2 hrs readings from both columns were taken for 24 hrs and graphs were plotted as below.

The values obtained for the conversion of nitrates for pretreated obtained was,

Y_c = -219 ln (t) + 552.2 with R^2=0.988 and

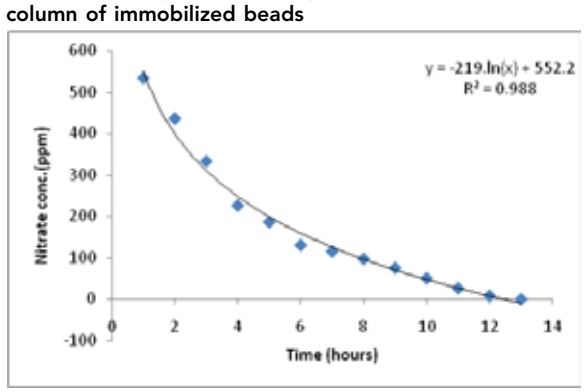
Untreated effluent was Y_c = -494 ln (t) + 1333 with R^2=0.96.

The above biological techniques to treat the toxic level of nitrates proved to be the best methods providing their availability, cheaper, faster and eco-friendly nature. The uses of ecofriendly methods enhance the sustainability of healthy environment.

Table1: Readings of nitrate levels after immobilization

TIME(Hours)	Nitrates in Pretreated effluent(ppm)	Nitrates in untreated effluent(ppm)
0 hrs	535	1198
2hrs	437	1016
4hrs	334	863
6hrs	227	703
8hrs	187	622
10hrs	131	523
12hrs	116	418
14hrs	98	322
16hrs	76	204
18hrs	51	114
20hrs	27	98
22hrs	9	63
24hrs	0.3	40

Table1: Readings taken every 2 hrs from the packed column of immobilized beads



Graph1: Nitrate conversion in Pretreated effluent
Conversion of nitrates explained in below modeling equation[9]:

Y=P ln(t)+Q , Where,

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Y_c is percentage conversion of nitrates,

T is the conversion time (in hours),P and Q are constants.

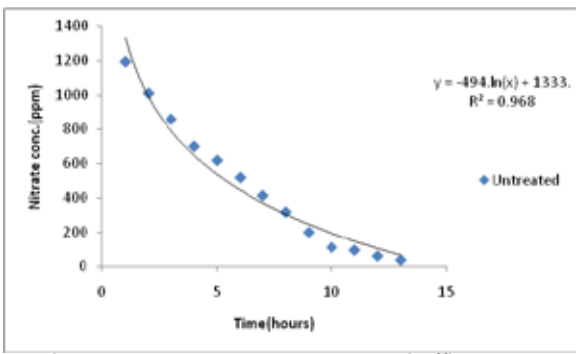
Nitrate conversion of Untreated effluent:

$Y_c = -219 \ln (t) + 552.2$

Where,

Y_c is percentage conversion of nitrates,

T is the conversion time (in hours)



Graph2: Nitrate conversion in Untreated effluent

The pretreated graph explains the conversion of nitrates 98% and untreated graph with the conversion of 96% after the effluent which was pretreated passed through the column with immobilized tamarind sodium alginate beads.

Modeling Equation derived from nitrate conversion for treated effluent:

$Y_c = -494 \ln (t) + 1333$

Where,

Y_c is percentage conversion of nitrates,

T is the conversion time (in hours).

Conclusion:

The seeds of ***Tamarindus indica*** were very good in reducing the nitrates to the minimal quantity in a very short period of time. These seeds proved to be easier, cheaper and ecofriendly in treating nitrate levels in the effluent. The immobization technique is the best method as it requries less space, time and easily reusable for a no. of runs to treat the effluent efficiently. The above biological techniques to treat the toxic level of nitrates proved to be the best methods providing their availability, cheaper, faster and ecofriendly nature. The uses of ecofriendly methods enhance the sustainability of healthy environment.

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