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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/18916
DOI URL: http://dx.doi.org/10.21474/IJAR01/18916

*RESEARCH ARTICLE*

# A REVIEW ON NEEM COATED UREA AS CONTROLLED RELEASE AGRICULTURAL FORMULATION

**Pinkey Bajaj Gandhi[1], Pooja Baweja[2] and Lata Vodwal[1]**

1. Department of Chemistry, Maitreyi College, University of Delhi, New Delhi-110021, India.
2. Department of Botany, Maitreyi College, University of Delhi, New Delhi-110021, India.

## Manuscript Info

***Manuscript History***
Received: 16 April 2024
Final Accepted: 21 May 2024
Published: June 2024

***Key words:-***
Fertilizer, Leaching, Nitrogen Utilization Efficiency (NUE), Controlled Release (CR), Neem Coated Urea (NCU)

## Abstract

Fertilizers are the chemicals that are added to soil so that necessary nutrients can be provided to the plants for increased crop production. Primarily Nitrogen (50-70%) is added to the soil as a conventional source of fertilizer. It is identified as the most significant element for the growth of the plants. In India, urea alone supplies about 82% of Nitrogen.As urea itself is highly water soluble, when it is mixed to the soil, immediately the leaching advances and as a result the Nitrogen utilization efficiency (NUE) by plants gets reduced. Therefore, it is essential to improve the formulation of the fertilizers in a way that it supplies nutrients as and when required for the proper plant growth and development. Controlled release (CR) agricultural formulations have long been recognized as the best solution to traditional formulations. With the implementation of slow-release fertilizers (SRFs), the requirement of fertilizers decreases as fertilizer use proficiency of the plants increases significantly. The use of SRFs may also reduce the environmental pollution. As a CR fertilizer the Neem coated urea (NCU) is ascertained as one of the best alternatives to supply the nutrient as per the demand of the plants and to reduce the environmental contamination.



## Introduction:-

Application of "Fertilizers- the plant's food" in the soil is a fundamental step to improvise plant development to attain increased crop yield[1][2][3]. Fertilizers provide essential nutrients such as nitrogen, phosphorus and potassium to the plants and thus ensure healthy growth[4][5][6]. Although fertilizers improve the overall growth, development and yield of crops, these are highly water soluble, easily leached from the soil, enter the water body and lead to eutrophication[7][8]. The excess of these fertilizers in water bodies becomes toxic for the aquatic animals, promotes the excessive growth of algae in water bodies and increases the biological oxygen demand (BOD), leading to the death of aquatic organisms[9][10]. Apart from eutrophication, high nitrates in ground-water also cause methemoglobinemia[11] (blue-baby syndrome), congenital disabilities, and gastric disorder in humans[12]. The ammonia derivatives and urea fertilizers are also the main source of ammonia volatilization[13], depositions in neighboring ecosystems through acid rains and finally damaging the vegetation[14].

Therefore, there is a necessity to develop fertilizers that improve NUE, reduce the amount required per unit area, and are environment friendly. Slow-release (SR) agricultural formulations have long been recognized as the best solution

**Corresponding Author:- Lata Vodwal**
Address:- Department of Chemistry, Maitreyi College, University of Delhi, New Delhi-110021, India.

to traditional formulations[14]. With the application of slow-release fertilizers (SRFs) dosage requirements are lower, labor cost decreases, fertilizer use efficiency is better and environmental contamination is reduced[15][16].

For this, Neem-coated urea is one of the best alternatives for meeting nutrient demands as controlled release fertilizer[17][18]. In NCU formulations, neem oil coats the surface of urea granules, making them less soluble in water and allows for gradual nutrient release (**Figure 1** and **Figure 2**). This results in more efficient nutrient uptake by plants and increase overall yield[19]. Previous studies have also discussed that neem oil acts as a nitrification inhibitor and also is a bioinsecticide.

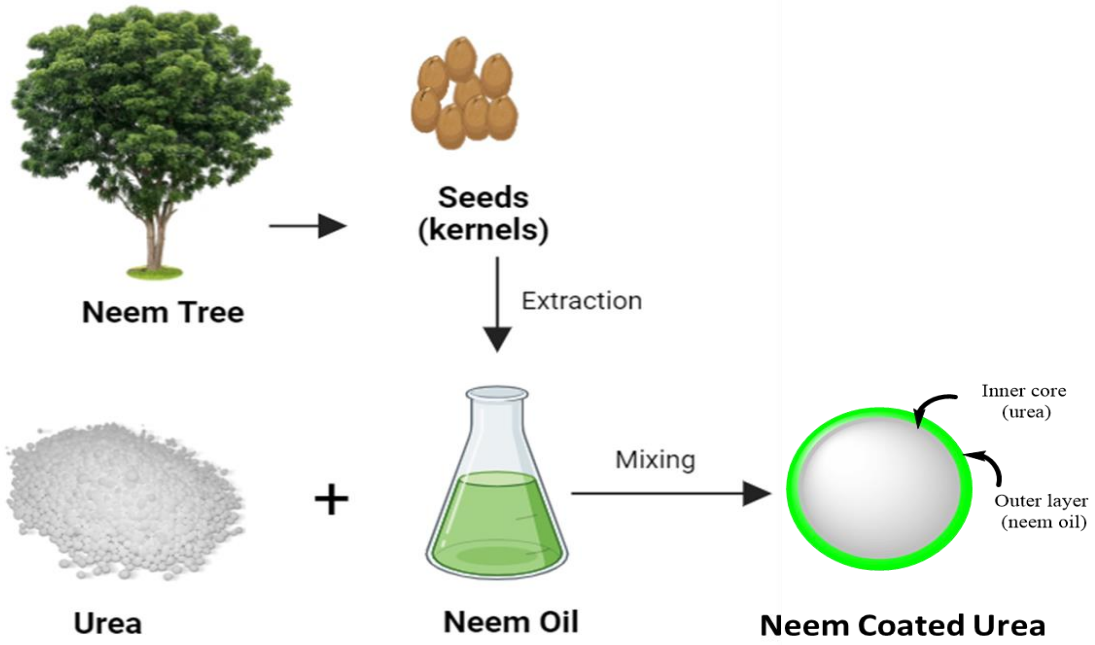


**Figure 1:-** Neem coated urea structure.

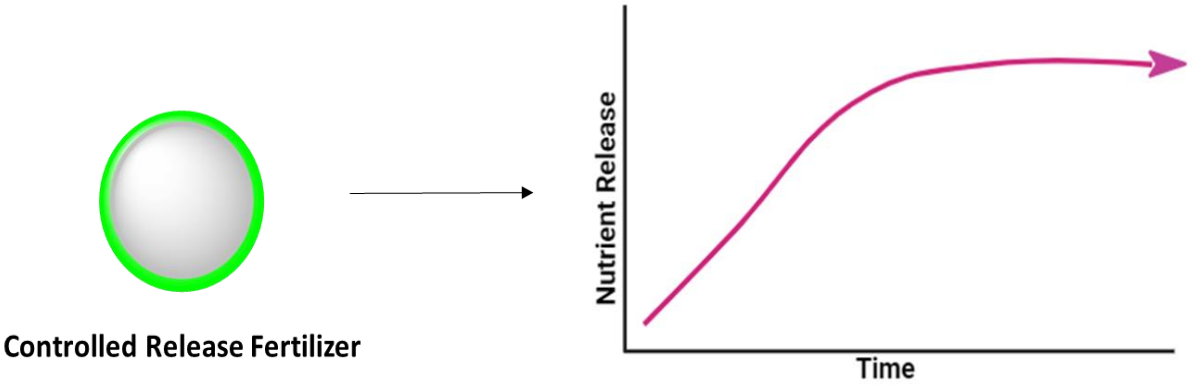


**Figure 2**:- Mathematical model of N release from NCU.

**Neem and Neem Oil**

*Azadirachta indica* commonly known as Neem (family Meliaceae) is native to the Indian subcontinent[20][21]. The neem tree has great relevance in organic farming. Its seeds or fruits are used for the extraction of neem oil which is rich in Azadirachtin, Nimbin, Salanin and Meliantriol. Neem oil is generally extracted through cold pressing technique which does not compromise with the content of bioactive compounds in the oil[22][23]. The oil extracted through cold press also matches with the specification of standard parameters of oil as suggested by the Department of Agriculture, Cooperation and Farmers Welfare, Government of India (2016) for the NCU formulation (**Table-1**)[17][19]. Overall per year approximately 85 kilo tonnes of Neem oil is produced in India[17].

**Table 1:-** Standard Parameters for Neem Oil[17]

| S. No. | Contents/Particulars | Value |
|---|---|---|
| 1. | Azadirachtin (AI) | 150 ppm |
| 2. | Iodine Value | 65-95 |
| 3. | Saponification value | 160-205 |
| 4. | Maximum moisture and insoluble matter percent by weight | 1.0 |
| 5. | Specific gravity at 30 $^{o}$C | 0.85-0.95 |

**Neem Coated Urea and its Action on Nitrifying Bacteria**

Urea ($NH_2$-CO-$NH_2$) is a white crystalline solid with 46% Nitrogen and high water solubility[24]. It is majorly used as a fertilizer to furnish the Nitrogen to the soil for plant growth and developments. Urea, when utilized as a fertilizer, undergoes a nitrification process which is a vital phenomenon by which Nitrogen from urea becomes directly available to crop plants. On the other hand if the nitrification is fast, it leads to significant loss of Nitrogen through nitrate leaching **(Figure 3)**. Due to the rapid nitrification NUE decreases affecting the growth of crops and ultimately decreasing the farmer's profitability. Neem oil majorly has tri-terpenes which are responsible for the inhibition of nitrifying bacteria. This unique characteristic of Neem oil makes it a potential oil for urea coating[25][26]. As soon as NCU is added to the fields, the tri-terpene content gets released and inhibits the activity of nitrifying bacteria. Thus, delaying the conversion of ammonical-N into nitrite-N significantly. As a result leaching of urea into the soil significantly gets reduced and also $N_2O$ emissions to the environment. Additionally, Neem oil is also used as biopesticide[27] therefore NCU formulation can also be used to prevent various pests populations such as mites, leafhoppers, and caterpillars.

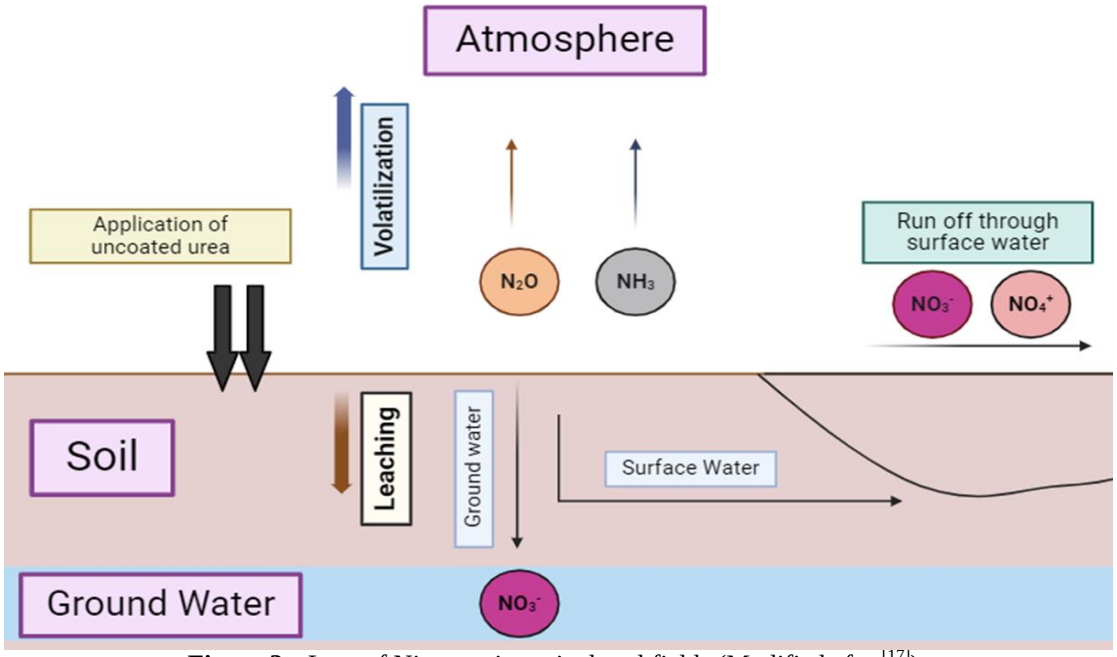


**Figure 3:-** Loss of Nitrogen in agricultural fields (Modified after[17]).

As per the notification S.O No. 2073 (E) dated August 10, 2009, the Government of India in 2009 has established the following parameters for Neem oil-coated urea[17] (**Table 2**).

**Table 2:-** Standard Parameter for Neem Coated Urea[17]

| S. No. | Contents/Particulars | Value |
|---|---|---|
| 1. | Azadirachtin (AI) | 150 ppm |
| 2. | Total Nitrogen ( %/ wt., minimum) | 46.0 |
| 3. | Biuret ( %/ wt., maximum) | 1.5 |
| 4. | Benzene soluble content ( %/ wt., maximum) | 0.035 |
| 5. | Maximum moisture and insoluble matter percentage by weight | 1.0 |

| | | |
|---|---|---|
| 6. | Specific gravity at 30 $^{o}$C<br>Particular size not less than 90% shall pass through 2.8 mm IS sieve and not less than 80% by wt. shall be retained on 1 mm IS sieve. | 0.85-0.95 |

**Process of Neem Coated Urea**

Urea granules can be prepared by various methods, but the fluidized bed technique is the oldest and most reliable process for coating[19]. Under this method, raw urea beads are taken in a fluidized bed drum and neem oil is slowly sprayed over the granules. The rotation of the drum and the spray of neem oil should be optimized so that the neem oil is evenly distributed over the surface of the urea. Lastly, the obtained NCU granules are dried using rotary dryers to remove the excess moisture. The flow diagram of the set-up for coating small coated granules is demonstrated in **Figure 4**.

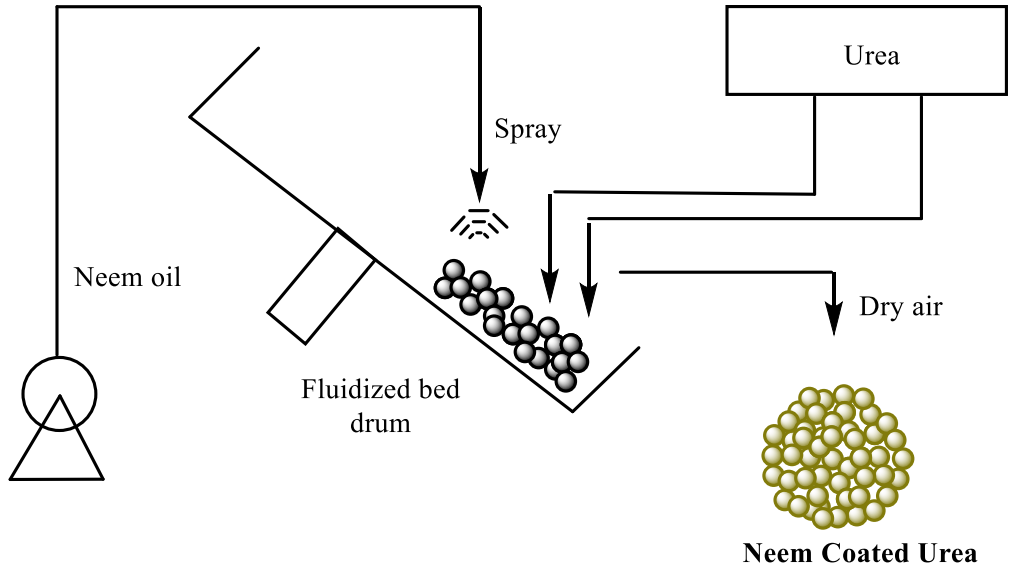


**Figure 4:-** The schematic diagram for the manufacture of Neem Coated Urea (Modified after[19]).

**Applications of Neem Coated Urea**

Neem oil used to coat the urea prills itself has insecticidal properties which are found effective against more than hundreds of insect species[28]. It also has pesticidal properties against some termites, nematodes and other pest species etc. NCU is completely non-toxic, eco friendly and environmentally safe. NCU promises numerous benefits in the agricultural sector due to its controlled release of Nitrogen and which ultimately makes the demand of Nitrogen for the growth of plants[29]. Some of the most significant applications are listed as:

1. Environment friendly.
2. Optimal plant development.
3. Less quantity of fertilizers required.
4. Simple application, saves labor and time
5. Growth parameters i.e. plant height, number of branches and dry weight has been found to be increased.
6. Reduces Nitrogen loss and gives monetary benefits to the farmers.
7. Indirectly involved in pest control.
8. Generate employment in rural areas.
9. Neem oil used to coat urea granules helps in reducing its caking process during the storage.

**Comparative Study of Raw Urea and NCU**

Neem coated urea is a green fertilizer developed to improve both soil health and NUE for the increased yields especially in Paddy fields[29]. The following parameters are used to compare uncoated urea and coated urea (**Table 3)**.

**Table 3:-** Comparative study of Uncoated Urea and Neem Coated Urea formulations[19]

| S. No. | Parameters | Uncoated Urea | Neem Coated Urea |
|---|---|---|---|
| 1. | Nitrogen % | 43.79 | 46.44 |

| | | | |
|---|---|---|---|
| 2. | Hygroscopicity | +++ | + |
| 3. | Solubility in water | +++ | ++ |
| 4. | Volatility | +++ | + |
| 5. | Nitrate Leaching | +++ | + |
| 6. | Denitrification | +++ | + |
| 7. | Granule collapse during manufacturing | +++ | ++ |

**Limitations of Neem Coated Urea**

In Spite of having numerous benefits in agricultural industries, there are also some limitations of NCU as listed below[29][30]:

1. Nutrients are not always released as predicted because of low temperature, flooded or drought soil.
2. The supply of neem does not match with the demand of NCU manufacturing industries.
3. The cost of manufacturing increases by 5% than conventional fertilizers.
4. NCU may not be available in all regional markets.
5. Neem oil is known as broad spectrum botanical insecticide therefore,it also affects non-targeted micro-organisms and insects.
6. Neem oil, being a natural product may degrade over time if not stored properly. Proper storage conditions such as avoiding exposure to sunlight and moisture are essential to maintain the stability and efficacy of Neem-coated urea during both storage and transportation.
7. The farmers are not very much aware regarding the government policies/ subsidy for NCU.

## Conclusion:-

The development of Neem-coated urea (NCU) as controlled release fertilizer (CRF) is a greener approach that not only minimizes the Nitrogen loss due to leaching and volatilization but also manages the Nitrogen release in a controlled wayso that nutrients supply matches with the plants demand. NCU also has a denitrifying factor which directly delays the conversion of ammonical-nitrogen into nitrate-nitrogen. In addition, Neem oil used for coating has bioinsecticidal properties and it can also prevent various pest populations. Neem-coated urea formulation is an innovative technique that aligns both Nitrogen Management and insect control and promises long-term viability for the crop production. It is highly recommended to the farmers looking to optimize their agricultural implementation while optimizing their environmental footprint.

## Acknowledgements:-

The authors are grateful to Maitreyi College, University of Delhi to provide necessary facilities for the successful completion of the manuscript.

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