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UTILISATION OF BIO-CHEMICAL PROPERTIES OF JUTE IN CONVERSION OF NON-ARABLE LATERITIC WASTELANDS

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ABSTRACT

Jute can be effectively used for conversion and reclamation of lateritic wastelands of our country to make them arable. It is a widely grown natural biodegradable, eco-friendly and cost-effective fibre. Jute contains useful chemical substances like lignin, hemi-cellulose, alpha-cellulose and other cellulose derivatives, which make significant contribution to pest-resistant and water retention properties of soil. They help to regulate the Carbon and Nitrogen cycle in the soil and also attract bacterial agglomeration.

We, on behalf of a voluntary organisation, carried out an experimental work at a lateritic wasteland at Garhbeta of Paschim Medinipur District of West Bengal to check soil erosion and improve fertility of land using jute geotextile. The soil has very low carbon and nitrogen content and is acidic in nature having no or very poor vegetation growth. After the experiment the land erosion has been completely restricted and due to bio-degradation of jute, the nitrogen and carbon content of the soil have increased considerably. The denuded wasteland has now become fertile and arable. The soil is gradually attaining the character of a 'medium soil' from a 'very poor' soil. The method is easily adoptable, cost-effective and eco-friendly as it uses only jute as the component for conversion of the land.

This paper has tried to correlate the unique bio-chemical properties of jute with the agricultural and geological findings of the field-trial.

Keywords: Conversion of Lateritic Wasteland, Bio-chemical Properties of Jute, Nitrogen fixation in soil, Soil fertility, Cost-effective, Eco-friendly.

1.0 INTRODUCTION

Fig 1 : Denuded Lateritic Wasteland at site

Like many other states within the lateritic belt of India, South Bengal suffer from miserable agriculture conditions due to lack of land fertility and adequate rainfall. A vast stretch of land is made of denuded lateritic soil, which has lost its fertility and is now prone to soil erosion due to indiscriminate deforestation (Figure-1). As there is very little scope of livelihood development, people in these areas suffer from poverty, illiteracy and malnutrition In these areas, peasants often abandon their ancestral denuded and erosion-prone land and migrate to urban conglomerations in search of better livelihood. The cause of anarchism and terrorism in these areas may also be attributed to lack of income generation activities particularly from the agriculture sector. The best solution to their problem is improvement of livelihood and localized income generation activity through sustainable cost-effective agriculture that yields cash crops.

The course of the rivers in these regions often get blocked or diverted due to heavy sedimentation caused by land erosion. Some sporadic efforts to check the erosion through afforestation did not produce the desired result, as the soil in general is not conducive for growth of plant due to its poor nutrient level. Checking of soil erosion using woven jute-based geotextiles is a proven solution to check soil erosion. A group of scientists and engineers of a voluntary organisation named FOSET along with a Research Institute of Central Govt. named NIRJAFT, visited an erosion-prone site at Ganganir Danga at Garhbeta to try jute geotextile to check land erosion. I took this opportunity to accompany them and apply my idea of using the unique bio-chemical properties of jute that would help in improving the soil nutrient content and convert the non-cultivable land into an arable one. Experimenting on this prospect, the very innovative technology using non-woven jute geotextile on non-culturable lateritic wasteland has been successfully implemented by the scientists of FOSET with the help of NIRJAFT at a land measuring 1.25 acres at Garhbeta of Paschim Medinipur district of West Bengal. I

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analysed the bio-chemical factors of jute that contributed the transformation of the land and conversion of degraded land into arable one.

The paper describes the fieldwork, the experimental findings and corroboration of the results with the theories. An exhaustive biological report on the qualities of jute and how it can be utilised on infertile lands to convert them into fertile ones has been described in this report.

2.0 OBJECTIVE OF THE PROJECT

Objective of the project as was envisaged by the scientists and engineers attached to FOSET and NIRJAFT were as follows:

1) Checking of soil erosion.
2) Development of soil quality by adding organic material due to decomposition of jute geotextile over the bare and unproductive lateritic surface of the study site.
3) Studying the bio-chemical properties of jute those are responsible for transformation of the land and growth of vegetation on it.
4) Establishing Jute Geotextile as a low cost, eco-friendly technique for soil conservation
5) Create suitable support for plant germination, reinforcement and growth in such areas designated as uncultivable wastelands.

3.0 FIELD-WORK

3.1 ORIGINAL CONDITION OF LAND

Our study area is at Garhbeta of Paschim Medinipur District. It has thick mantle of laterite occupying the high lands. The region is full of loose and dry surface soil with presence of highly indurated duricrust (Figure-2). The sediments of the area are mostly concealed under a blanket of duricrust. Laterite is heavily leached tropical subsoil. When exposed and dried it sometimes appears as rock-like. Low productivity of land, poor ability of land to hold water, scanty water supply during dry season, does not pose any dream to the eyes of the farmer and people in this locality. The soil has very low NPK (Nitrogen, Phosphorus, Potassium levels) due to lack of nitrogen fixing microbes in soil. The soil also lacks moisture-holding ability due to porosity and rockiness.

Fig-2: Top soil - Indurated duricrust

3.2 METHODOLOGY

The land was tilled manually at the onset of monsoon and 6mm thick non-woven Jute geo-textile having weight of 400gm/m^2 was laid on it with intermediate pegging to prevent slippage (Figure-3). This jute geotextile is 100% organic and have water absorption capacity of about 85% by weight.

Local soil was spread on the geo-textile for a thickness of about 75 to 100 mm and the land was made ready for cultivation during monsoon (Figure-4). Vermicompost has been applied at the initial stages of land preparation.

Intercropping has been made among maize, black gram, green gram cowpea, ground- nut etc. Growth of root and plant was noted time-to-time on regular interval and the data on rainfall and soil moisture content were also taken.

Fig.3: Jute Geotextile is being laid

Fig.4: Local soil is being spread over geotextile

3.2 CHOICE OF CROPS

Figure 5: The decomposed status of the fibre after 1 monsoon.

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Care was taken about the crops grown on the substantially prepared land. Extensively nutrient-depleting crop can pose harm to the soil as it is young in nitrogen. For this reason rice, wheat and sugarcane were not chosen. For prior experimentation we selected crops like maize, lemongrass, groundnut, pigeon pea etc. which requires less water and is common to this agro-climatic region

3.2.1 REASON FOR GROWING THE MENTIONED CROPS:

1) Most of them are leguminous and allow better microbial conglomeration.
2) The crops are drought resistant and can survive dearth of water.
3) The geotropic affinity of the plants must be high or in other words the plants must be hardy with increased root growth.
4) The plants must not be nutrient or moisture depleting but must help in maintaining soil fertility by fixing atmospheric nitrogen.

3.3 FACILITATION OF ROOT GROWTH

After the monsoon spells the laid jute has decomposed partially (Figure-5) and has added to the soil nutrients and fertility (See Table-2). The seeds begin to germinate and their radicle begins to develop into root which is the main criterion determining the fate of the crop.

Early root growth is one of the functions of the apical meristem (Figure-6)[i] located near the tip of the root. The meristem cells continuously divide itself producing more meristem, root cap cells and undifferentiated root cells. The latter become the primary tissues of the root. It undergoes elongation by which the the root tip pushes forward in the medium. Gradually these cells differentiate and mature into specialized cells of the root tissues.

Roots will generally grow in any direction where the correct environment of air, mineral nutrients and water exists to meet the plant's needs. At germination, roots grow downward due to gravitropism.

The distribution of vascular plant roots within the soil depends on the form of the plant, availability of water and nutrients, and the physical properties of the soil. The majority of roots of most plants are found relatively close to the surface where availability of nutrient and aeration around roots are more favourable for growth.

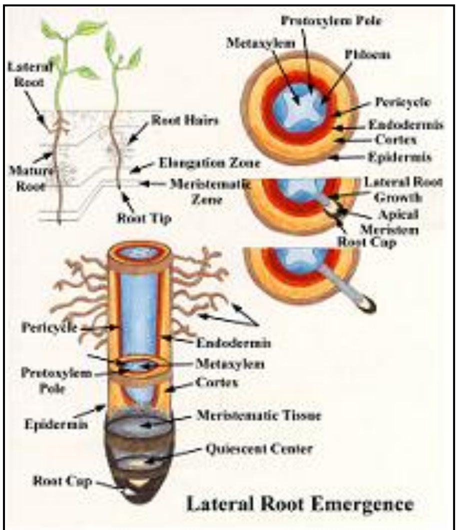

Figure 6: Apical meristem of root
Source: http://www2.puc.edu/Faculty/Gilbert_Muth/art0060.jpg

4.0 RESULTS

At this point of my project I would like to mention that the experimentation of this innovative technology was done in a small portion of land measuring 1.25 acres at Garhbeta of Paschim Medinipur district. The results and statistics I am going to laminate now are taken from the report of the scientists working with FOSET on this technology and theoretically analyzing the results with the change in soil characteristics.

4.1 BEFORE COMMENCEMENT OF THE PROJECT

a) Lateritic denuded wasteland which is highly prone to erosion
b) Very poor NPK and soil moisture content as detailed in Table-1 and comparison give with that of medium-grade soil[ii]

	Percentage of Organic Carbon	Percentage of Total Nitrogen*	Nutrient content (kg ha^{-1})		Soil p^H
			P_2O_5	K_2O	
Site	0.21	0.04	28.8	120.0	5.1 (Acidic)
Normal for Medium soil	0.75 – 1.5	0.076 – 0.13	45 – 90	150 – 340	6.5 – 7.5 (Neutral)
* Calculated using empirical formulae: Total Nitrogen = 0.026 + 0.067 x Organic Carbon[iii]					

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Table-1 : Soil character analysis result before start of project

4.2 AFTER 100 DAYS OF IMPLEMENTATION

a) 60-70% restriction of sediment movement,
b) 57% rise in Organic Carbon, 20% increase of nitrogen content in soil, 75% increase of potassium, 37.5% increase in phosphorous (Table-2).
c) Rapid root development of certain vegetation like Lemon grass, Maize, Green Gram, Kalai, Arhar etc. (Figure –7)
d) Growth of plant was satisfactory.
e) Moderate Increase in percentage of silt and clay
f) Sign of change in physical nature of the soil including the moisture content.

Fig.7: Root development through geotextile

	Percentage of Organic Carbon	Percentage of Total Nitrogen*	Nutrient content (kg ha^{-1})		Soil p^{H}
			P_2O_5	K_2O	
Site	0.21	0.04	28.8	120.0	5.1 (Acidic)
Normal for Medium soil	0.75 – 1.5	0.076 – 0.13	45 – 90	150 – 340	6.5 – 7.5 (Neutral)
After 100 days at Site	0.33	0.048	39.6	210.0	6.1 (Slightly acidic)

* Calculated using empirical formulae: Total Nitrogen = 0.026 + 0.067 x Organic Carbon

Table-2 : Soil character analysis result after 100 days

4.3 AFTER 300 DAYS OF IMPLEMENTATION

a) Total restriction of sediment movement
b) 50% increase of nitrogen content in soil, 125% increase of potassium, 75% increase in phosphorous and 142% increase in organic carbon (Table-3).
c) 90- 95% of the seeds germinated
d) Survival rate has been 85-90%. (Figure– 8)
e) Penetration of roots into the soil is satisfactory.
f) Plant height was in correlation with the root growth
g) Sufficient Increase in percentage of silt and clay
h) Significant change in physical nature of the soil including the moisture content.

	Percentage of Organic Carbon	Percentage of Total Nitrogen*	Nutrient content (kg ha^{-1})		Soil p^{H}
			P_2O_5	K_2O	
Site	0.21	0.04	28.8	120.0	5.1 (Acidic)
Normal for Medium soil	0.75 – 1.5	0.076 – 0.13	45 – 90	150 – 340	6.5 – 7.5 (Neutral)
After 100 days at Site	0.33	0.048	39.6	210.0	6.1 (Slightly acidic)
After 300 days at Site	0.51	0.06	50.4	270.0	7.0 (Neutral)

* Calculated using empirical formulae: Total Nitrogen = 0.026 + 0.067 x Organic Carbon

Table-3 : Soil character analysis result after 300 days

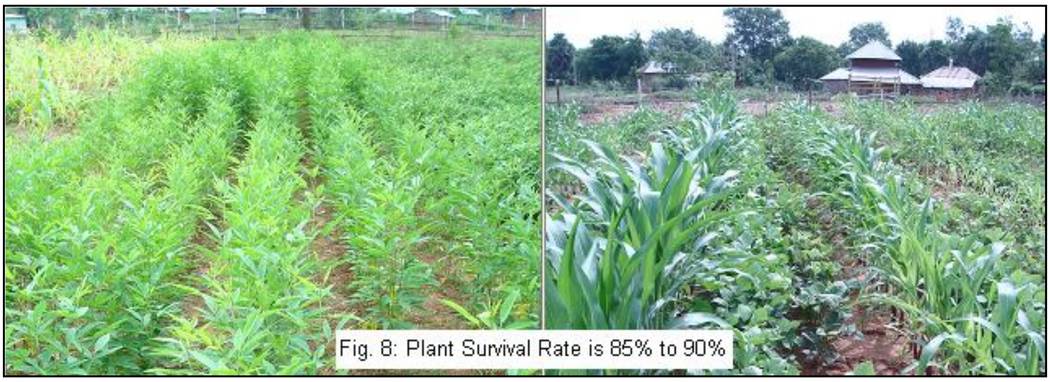

Fig. 8: Plant Survival Rate is 85% to 90%

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4.4 AFTER 450 DAYS OF IMPLEMENTATION

a) Total restriction of sediment movement
b) 57.5% increase of nitrogen content in soil, 173% increase of potassium, 89% increase in phosphorous and 161% increase in organic carbon (Table-4).
c) 97- 100% of the seeds germinated
d) Survival rate has been 93-95%
e) Penetration of roots into the soil has improved.
f) Plant height was in correlation with the root growth
g) The character of the soil has completely changed and it is now ready for cultivation of local commercial crops like beans, ground nuts, maize (Figure-9) etc.

	Percentage of Organic Carbon	Percentage of Total Nitrogen*	Nutrient content (kg ha^{-1})		Soil p^H
			P_2O_5	K_2O	
Site	0.21	0.04	28.8	120.0	5.1 (Acidic)
Normal for Medium soil	0.75 – 1.5	0.076 – 0.13	45 – 90	150 – 340	6.5 – 7.5 (Neutral)
After 100 days at Site	0.33	0.048	39.6	210.0	6.1 (Slightly acidic)
After 300 days at Site	0.51	0.06	50.4	270.0	7.0 (Neutral)
After 450 days at Site	0.55	0.063	54.5	328.0	7.1 (Neutral)

* Calculated using empirical formulae: Total Nitrogen = 0.026 + 0.067 x Organic Carbon

Table-4 : Soil character analysis result after 450 days

Fig. 9: Produces from the converted land - Maize, Green Gram, Black Gram, Ground Nut

5.0 ANALYSIS OF BIO-CHEMICAL FACTORS OF JUTE WHICH LED TO THE ABOVE RESULTS

The choice of Jute Geotextile in conversion of degraded lateritic wasteland is bestowed on the biological composition of this natural bio-degradable fibre and the microbial activities created on addition of this to the soil plays the major role.

5.1 BIOLOGICAL COMPOSITION

Jute is a ligno-cellulosic bast fibre. The basic constituent of jute is cellulose whose empirical formula is $(C_6H_{10}O_5)_n$.
The range of composition is:
Lignin: 12-14%
α-cellulose: 58-63%
Hemicellulose: 21-24%[iv]

5.1.1 LIGNIN (12-14)%

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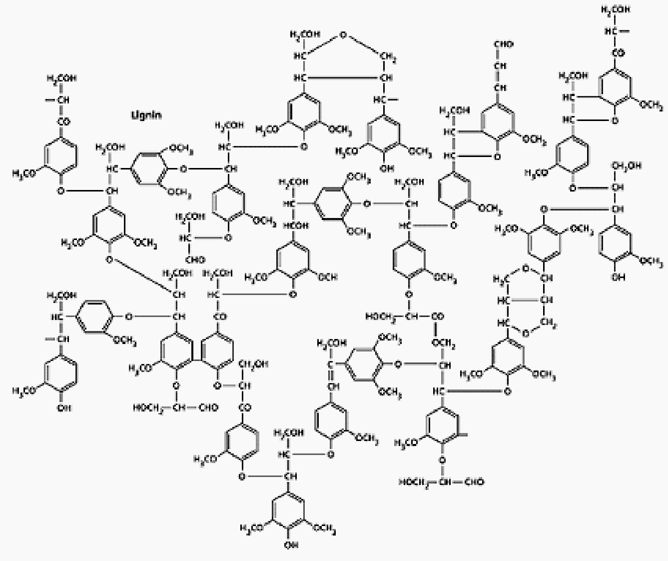

Figure 10 : Lignin molecule

Lignin fills the spaces in the cell wall between cellulose, hemicellulose, and pectin components, especially in tracheids, sclereids and xylem (Figure-10). It is covalently linked to hemicellulose and thereby crosslinks different plant polysaccharides, conferring mechanical strength to the cell wall and by extension the plant as a whole. Lignin takes a major role in conducting water in plant stems. The polysaccharide components of plant cell walls are highly hydrophilic and thus permeable to water, whereas lignin is more hydrophobic. The crosslinking of polysaccharides by lignin is an obstacle for water absorption to the cell wall. Thus, lignin makes it possible for the plant's vascular tissue to conduct water efficiently. Lignin is indigestible by animal enzymes, but some fungi and bacteria are able to secrete ligninases which can biodegrade the polymer. The presence of lignin makes the fibre more resistant to rotting i.e. fungal attack. Lignin plays a significant role in the carbon cycle, sequestering atmospheric carbon into the living tissues of woody perennial vegetation. Lignin is one of the most slowly decomposing components of dead vegetation. Thus it retains the carbon from the atmosphere for a much longer time period and also contributes a major fraction of the material that becomes humus as it decomposes. The resulting soil humus generally increases the photosynthetic productivity of plant communities growing on a site as the site transitions from disturbed mineral soil through the stages of ecological succession, by providing increased cation exchange capacity in the soil and expanding the capacity of moisture retention between flood and drought conditions

5.1.2 HEMICELLULOSE (21-24) % AND α-CELLULOSE (58-63) %

both α-cellulose (Figure-11) and hemicellulose have the same function in terms of improving the soil clarity. A substantial increase in the organic matter of the soil leads to increased secretions of flavonoids and betaines from the root hair cells of leguminous plants, which in turn leads to the growth of an infection thread acquisition of symbiotic microbes within the root nodules.

Increased carbohydrate concentrations also provide a base for free living bacteria and cyanobacteria, which in turn increase the N content of the soil.

Being a carbon reservoir, jute (both *Corchorus capsularis* and *Corchorus olitorius*) enhances the carbon cycle of the soil.

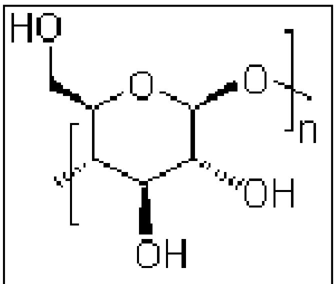

Figure 11: α-cellulose molecule

5.1.3 CELLULOSE DERIVATIVES

In addition, analysis of the hemicellulose isolated from α-cellulose and lignin gives xylan 8% - 12.5% (Figure-12); galactan 2% - 4%; glucuronic acid 3% - 4%; together with traces of araban and rhamnosan. The insoluble residue of α-cellulose has the composition glucosan 55% - 59%; xylan 1.8% - 3.0%; glucuronic acid 0.8% - 1.2%; together with traces of galactan, araban, mannan, and rhamnosan. All percentages refer to the weight of dry fibre. All of these enhance cation exchange and carbon cycle.[v]

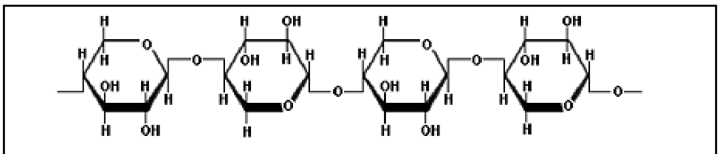

Figure 12: Hemicellulose molecule

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5.2 DEVELOPMENT OF MICROBIAL AFFINITY

Jute adds sufficient organic material for development of microbial agglomeration. Some of these microbes are:

5.2.1 FREE LIVING NITROGEN FIXING BACTERIA
Azotobacter (Figure-13)[vi], *Clostridium, Desulphovibrio* etc

5.2.2 FREE LIVING NITROGEN FIXING CYANOBACTERIA
Anabaena, Nostoc (Figure-14)[vii], *Aulosira*

5.2.3 SYMBIOTIC NITROGEN FIXING BACTERIA
Rhizobium (Figure-15)[viii], *Xanthomonas*

5.2.4 SYMBIOTIC NITROGEN FIXING CYANOBACTERIA[ix]
Azolla pinnata, Anabaena azollae (Figure-16)


Figure-13: *Azotobacter*


Figure-14: *Nostoc*


Figure-15: *Rhizobium*


Figure-16: *Anaebena azollae*

Root of a legume secrets chemical attractants like flavonoids and betaines. Bacteria deposit over the root hairs, release nod factors, which cause curling of root hair around the bacteria, degradation of cell wall and formation of an infection thread enclosing the bacteria (Figure-17)[x]. Infection thread grows along with multiplication of bacteria. It branches and come to lie opposite protoxylem points of the vascular strand. The infected cortical cells differentiate and start dividing producing nodules. Nodule formation is stimulated by auxin produced by cortical cells and cytokinin liberated by invading bacteria. The infected cells enlarge. Bacteria stop dividing and form irregular polyhedral structures called bacteriods. However same bacteria retain normal structure, divide and invade new areas. In an infected cell bacteroides (Figure-18) occur in groups surrounded by host membrane. The host cell develops a pinkish pigment called leghaemoglobin. It is oxygen scavenger and protects nitrogen fixing enzyme nitrogenase from oxygen.

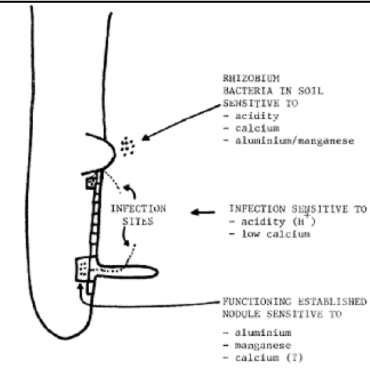

Figure 17: Infection thread enclosing the bacteria

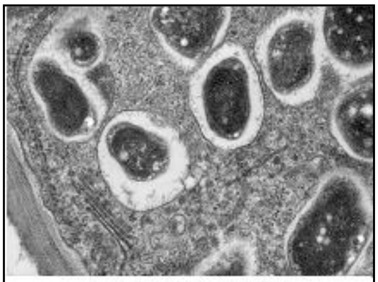
Figure 18: Bacteroids

5.3 MECHANISM OF NITROGEN FIXATION[xi]

Nitrogen fixation requires:

a) A reducing power like NADPH, $FMNH_2$
b) A source of energy like ATP
c) Enzyme nitrogenase
d) Compounds for trapping NH_3 formed by the reduction of dinitrogen.

Enzyme nitrogenase has Ferrum (Iron) and Molybdenum. Both of them are crucial in attaching of a molecule of Nitrogen. Bonds between the two atoms of Nitrogen get weakened by their attachment to

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the metallic components. The weakened molecule of nitrogen is acted upon by Hydrogen from a reduced coenzyme. It produces dimide (N_2H_2), Hydrazine(N_2H_4) and then Ammonia($2NH_3$)
Biological nitrogen fixation can be represented by the Equation-1, in which two moles of ammonia are produced from one mole of nitrogen gas, at the expense of 16 moles of ATP and a supply of electrons and protons or hydrogen ions.

Equation:1
$N_2 + 8H^+ + 8e^- + 16\ ATP = 2NH_3 + H_2 + 16ADP + 16\ Pi$

This reaction is performed exclusively by prokaryotes, using a complex enzyme termed nitrogenase. This enzyme consists of two proteins - an iron protein and a molybdenum-iron protein.
The reactions occur while N_2 is bound to the nitrogenase enzyme complex. The iron protein is first reduced by electrons donated by ferredoxin. Then the reduced iron protein binds ATP and reduces the molybdenum-iron protein, which donates electrons to N_2, producing HN=NH. In two further cycles of this process (each requiring electrons donated by ferredoxin) HN=NH is reduced to $H_2N\text{-}NH_2$, and this in turn is reduced to $2NH_3$.[xii]

5.3.1 NITRIFICATION

It is the phenomenon of conversion of ammonium nitrogen to nitrate nitrogen, which is performed in 2 steps:

a) Nitrite formation
b) Nitrate formation

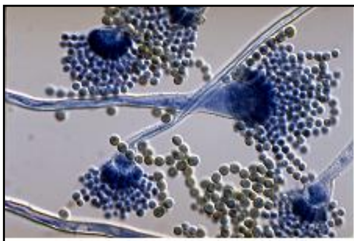
Figure 19: *Aspergillus flavus*


Figure 20: *Nitrosomonas*

Both the steps can be carried out by *Aspergillus flavus* (Figure-19).
In the 1st step, ammonium ions are oxidized to nitrites by *Nitrosococcus, Nitrosomonas* (Figure-20). Nitrites are changed to nitrates in the 2nd step by *Nitrocystis, Nitrobacter*.
Nitrification is a process of nitrogen compound oxidation i.e. loss of electrons from the nitrogen atom to the oxygen atoms. The process has been detailed in Equation-2, Equation-3, Equation-4 and Equation-5.

Equation-2:
$NH_3 + CO_2 + 1.5\ O_2 + \textit{Nitrosomonas} \rightarrow NO_2^- + H_2O + H^+$
Equation-3:
$NO_2^- + CO_2 + 0.5\ O_2 + \textit{Nitrobacter} \rightarrow NO_3^-$
Equation-4:
$NH_3 + O_2 \rightarrow NO_2^- + 3H^+ + 2e^-$
Equation-5:
$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$

5.3.2 DENITRIFICATION

Some microbes use nitrate and other oxidized ions as sources of oxygen. In the process nitrates are reduced to gaseous compounds of nitrogen. The latter escapes from the soil.
Common bacteria causing denitrification of soil are *Pseudomonas denitrficans* (Figure-21), *Thiobacillus denitrificans*, *Micrococcus denitrificans etc.*
Denitrification process can be expressed through some combination of the intermediate forms as mentioned in Equation-6:

Equation-6:
$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2\ (g)$

The complete denitrification process can be expressed as a redox reaction (Equation-7):

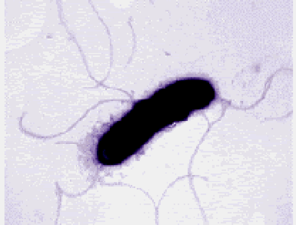
Figure 21: *Pseudomonas denitrficans*

Equation-7:
$$2\ NO_3^- + 10\ e^- + 12\ H^+ \rightarrow N_2 + 6\ H_2O$$

6.0 A COST- EFFECTIVE BIO-ENGINEERING TECHNIQUE HAVING BIO-CHEMICAL APPLICATION OF PROPERTIES OF JUTE

Use of Jute Geotextiles to convert lateritic wastelands has came to be a very cost-effective bio-engineering technique that is a unique mixture of biology, chemistry, engineering and bio-technology.

The cost of the field-work (excluding the cost incurred for data-collection, transportation etc.) at a very small-scale level on a 1.25 Acre of land at Garhbeta has been computed in Table-5:

Sl.	Item	Cost (₹)
1.	Jute Geotextile	75,000.00
2.	Labour, fertiliser, seed and plot management charges for two years	50,000.00
3.	Irrigation	30,000.00
	TOTAL	1,55,000.00

Table5: Cost of Labour and Material at Garhbeta

The figures in Table-5 indicate that cost per acre (3 bighas) would be ₹1,24,000.00. However item no. 2 is common for all type of land and a part of the labour cost can be included in the ongoing National Rural Employment Guarantee Scheme (100 days job).
In that case the cost per Acre (3.025 Bighas) for conversion would be ₹84,000.00 only. Considering one Acre of land per family at rural areas of West Bengal, expense for providing adequate arable land to each family of this down-trodden will be only ₹60,000.00 (Item 2 to be met from NREGS programme and item 3 is common for all agricultural activity)
(₹ = Indian Rupees; ₹100 = USD 2.14 as in May 2010;
1 Acre = 4046.86 sq.m.; 1 Bigha in West Bengal = 1333.33 sq.m.)

7.0 CONCLUSION

Coming to the terminal of my report I would like to express some of my personal thoughts:

- India has approximately 3,69850 ha of area as red lateritic wasteland.[xiii] It is stretched within the states of West Bengal, Jharkhand, Orissa, Chattisgarh, Maharashtra and Andhra Pradesh. The areas remain unutilised for over a long period of time.
- The problem of land rehabilitation could have been achieved by genetically advanced techniques of cultivation based on our indigenous research
- But the problem here is very simple…..”MONEY”… We don’t have so much of that.
- But that does not mean we will not care for our poor peasants who know how to cultivate but cannot do so due to lack of proper land.
- We the better-literates of India must put forward a helping hand of our hard learnt science and technology to the benefit of these people.
- This bio-engineering technique of using jute geotextile to convert lateritic wasteland can play a crucial role in providing livelihood opportunities to common people.
- The unique bio-chemical properties of jute are capable of transforming the non-culturable lateritic wasteland in not only West Bengal, but also other parts of the country.
- Considering the unrest and extremist activities in these regions, the Government is also considering development of economic generation activities for the poor people and this technique may provide a very cost-effective and appropriate solution to the efforts of the government.
- Such experiment should be extended to other type of non-culturable land like deserts, marshy lands etc.
- The soil of this lateritic zone was found to be acidic and low in carbon, nitrogen and other nutrient content. We may consider mixing coal-ash (fly ash) generated from the thermal power stations, which is alkaline in character, high in carbon content and have some useful chemicals like Calcium oxide (CaO), Iron oxide (Fe_2O_3) etc. While fly ash will help in improving the carbon and mineral content, jute will contribute to nitrogen fixation. The alkaline fly ash will neutralize the acidic lateritic soil very soon. The experiment

may be repeated by mixing small quantity of fly ash prior to laying of jute geotextile and it is expected that it will improve the soil character faster than the experiment carried out by us.

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