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The Preservation Methods of Colonial Forest Timbers: A Perspicacious View

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The articulation of any concrete environmental policy witnessed retention of natural landscapes and withdrawal of any allows of destruction of natural resources and consequent export to other nations. Such retention no doubt seems to be very obvious to indigenous power groups but appears to be a mismatch strategy to a foreign imperial power. Indian forestry between 1865-1947 witnessed such total destruction and exportation of forest products and more particularly the timbers. The opening of Indian forest department in 1864 and its grand restructuring into Imperial Forest Research Institute in 1906 bore testimony to this phenomenon where application of science was made to treat the Timbers to increase its sustainability and durability. The present paper wishes to highlight the treatment procedures that were developed by the forest Research Institute.

The destructive forces of World War I proved unhindered to the working of Forest Research Institute, established in 1906 and this is evident, as better utilization of forest products as a means of forest conservation rapidly gained ground with the advancement of scientific investigation under the imperial institute soon after its opening or more particularly in the successive years following the outbreak of World War I. So as to speak of the colonial pose it seemed always to confer the application of European modes of conservation or more generally or categorically to say application of scientific principles of conservation on Indian forests. Scientific forestry so to say was nothing but the concept meticulously concealed the colonial extraction process of Indian Forests. Imperial Forests were maintained for two primary reasons(i) for the supply of timber, fire wood and other produce (ii) for forest itself which had beneficial effects on climate, water supplies, protection against erosion and desiccation[1] and towards other directions. Most forests of the latter category came under the head of 'protection forests'[2]. They affect the welfare and even the safety of communities, and hence the right of state to exercise control over them was generally admitted. Thus in the 'protection forests'[3] the law imposed state control over the forests. The present article wishes to highlight the colonial attempt to treat the timbers for its better preservation and storage.

The working of Imperial Forest Research Institute (1906) of Dehradun was a great example in regard to utilization of forest products by the state. In fact, scientific investigation with forest produce and its beginning after 1906 gained considerable progress with the establishment of Forest Research Institute in 1906. The present article mainly highlights the seasoning and preservation methods that were employed by the Forest Research Institute which ensured better utilization of Forest products[4].

The Development of the study of Forest woods during the Colonial period

A detailed study of Forest woods and their suitability for various uses, depending on certain technical properties were made. The following divisions of the study of trees were the most important.[5]

1) Anatomical structure
2) Shape and size of trees
3) Specific gravity
4) Hardness
5) Flexibility
6) Elasticity
7) Flexibility
8) Strength
9) Seasoning power and liability to be affected by moisture.
10) Durability
11) Combustibility and heating power
12) Colour, grain and other properties
13) Freedom or otherwise from defects or unsoundness.

Research on Anatomical Structure of Wood

If the sawn end of a log of timber be examined, it would be seen that the wood was being marked with certain definite marks. In the centre would be formed a small soft mass of tissue known as pith, round which were numbers of concentric rings, sometimes called annual rings, which usually represented the wood produced during one growing season, vary greatly in width, being broad in fast-grown and narrow in slow-grown timber in many times they were not visible. Radiating from the centre outwards were numbers of fine lines, known as 'medullary rays', which vary in distinctness according to the species of timber. Outside the wood was the cortex (popularly termed "bark"), while, between the wood and the cortex was the cambium, a thin layer of soft tissue which, as it grows, produced wood to the inside and cortex to the outside. If the log be split open, it would be found that the concentric rings which had already been seen in cross section were really concentric hollow cylinders of wood laid on one above the other, and which in longitudinal section produce the "grain of the wood"[7]. The chief factors which influenced the shape and dimensions of trees, as well as the proportion of stem wood, broken wood, and root wood, were (i) the species, (2) density of the crop (3) the age of the tree (4) the soil and locality (5) the Sylvicultural system adopted[8].

During this phase in the post first World War phase ,the most important conifers were the deodar (Cedrus deodara), the pines (pinus excelsa and longifolia), the spruce (Picea Morinda), and the silver fir (Abies pindrow). Pinus Longifolia had for many years been managed in Kinmaun under the shelter wood compartment system, this management had been extended to the Punjab Forests. Regeneration was comparatively easy with six to eight good seed-bearers to the acre, if only fire protection could be obtained. Due to the incendiary fires of 1921 the working plans branch in the United Provinces had been considering whether it might not be necessary in the future to take a step backward and to adopt the modified system employed by the French[9] in the pine forests of Corsica. The blue pine (P. excelsa) in the Punjab was regenerated in a similar way, only more seed bearers were retained, and an admixture of deodar was generally attempted either by reserving this species among the trees or by artificial sowing and planting[10].

The deodar was by far the most valuable of the conifers, and forests containing this tree had been under management for nearly 50 years. The system in force was the shelter wood compartment system, leaving the mother trees 30-59 - feet apart[11].

Various forms of Sylvicultural System

There were various types of Sylvicultural system they were[12]

(a) The clear cutting system
(b) The uniform method (system of successive feelings)
(c) The group system
(d) The selection system
(e) Two-storied high forest
(f) Coppice
(g) Coppice with standards

A suitable sylvicultural study studied the high quality of a tree whose boles should have four chief qualities – cleaners, straightness, cylindrical shape and suitable dimensions. Sylviculture taught how to grow trees having these qualities, the quantity of a wood depended on the spices and local conditions of its growth.

Specific Gravity of Wood

The determination of the specific gravity of wood was explained in the 'Manual of Forest Mensuration'. They were;[13]

(a) Instrument used for the height measurement of trees
  (i) Simple plumb-line clinometers
  (ii) Brandis Hypsometer
  (iii) Planchet's Clinometers
  (iv) Mr. A. Smythees's Dendrometer
  (v) Weise's Dendrometer (obtainable through Herr Wilhelm Sperhare , 37, stein strasse, Gissen, Germany
  (vi) Christen's Dendrometer (obtainable through Herr Wilhelm Sperhare, 37, Stein Strasse, Giessen, Germany)
  (vii) Abney's level (obtainable from the mathematical Instrument Office, Calcutta, price in leather case, Rs.25)[14]

Methods of Measurement of Trees

(i) Measurement with Tapes and Calipers
(ii) Girth measurement with canes (usually adopted in Burma where large quantities of teak timber, usually floating in rafts, had to be measured).
(iii) Allowance for bark – whether bark was included in the volume measurement or not was largely a matter of local custom, due allowance was being made in the price of the log when bark was included. To measure a log without including the bark it was sufficient to

cut off a strip of bark 3 or 4 inches wide round the canine of the log, so that the tap or measuring came might lie against the wood.

(iv) Abnormal swelling on log-If the log had an abnormal swelling or depression at its centre two girths should be taken at equidistant points on either side of the centre and the mean taken as the required girth.[15]

(v) Volume of heartwood and sapwood was required separately; diameter measurements at each end of the Log should be made respectively for (a) the whole thickness of the log (without bark) and (b) the breadth of heartwood only.

The volume of heart wood subtracted from the total volume would then give the volume of Sapwood[16]. Where the surface was not circular it was advisable to take the mean of two diameters at right angles. If quarter-girth squared measurement was required, the total girths of the ends of the log instead of the diameters might be measured. Diameter measurements, however, were necessary for the heartwood, and these could be converted to girth measurements before working out the result.

On the other hand if the timber was of equal dimensions all along its length, the volume got by the product of length breadth x depth. If the timber tapers regularly from one end to the other, measure the breadth (bm) and depth (dm) at its centre, & the volume will be $1x^{b}mx^{d}m$, or measure the breadth and depth at each end.[17]

The volume of scantlings and planks of rectangular section was given by the product of length breadth x depth. The length is usually given in feet and the breadth and depth in inches in which case volume (in cubic feet) [18]

The Development of the Methods of Seasoning Wood [19]

There were various methods of seasoning timber, of which the following were the principal:-

(i) Natural seasoning

(ii) Water seasoning

(a) In Fresh Water

(b) In Salt Water

(iii) Artificial Seasoning.

Natural Seasoning

This consisted of exposing the wood to the drying action of the atmosphere without employing any artificial means of extracting the moisture from it. Timber should be allowed to season evenly and not too rapidly, and should therefore be placed in an airy situation, raised above the damp ground, and not exposed to sun and rain. In actual practice logs were frequently left lying in the forest for some time, and became partly seasoned there. In this case exposure to strong sun and rain alternately should be avoided as much as possible by placing the logs in a shady place and the logs should be turned over occasionally.

Scantlings should be sawn from seasoned or partly seasoned logs and should be left to season further before use. The barking of logs hastened seasoning, but might induce cracks. In Burma teak trees are killed by girdling three days before felling, in order to render the timber light enough to float. The timber thus was fairly well seasoned before the tree was felled. Fire wood should be seasoned as rapidly as possible, and should therefore be cut and stacked in the dry weather[20].

(2) Water Seasoning

(a) Fresh Water – The method of water seasoning was a common one, its chief advantages being that it shortened the time required for subsequent drying, promoted more even seasoning and in the case of soft white woods prevented the discoloration which frequently took place when the wood was air-seasoned in the log. In water-seasoning green timber was entirely immersed in fresh water for a period of time which might vary from two weeks to six months, it was then taken out of the water and subjected to the process of natural seasoning already described, the time required for seasoning being shortened by the immersion in water, which should be completed and not –partial. The water should if possible be running water, stagnant pools being avoided. Teak, Sal, Dalbergia latifolia and Terminalia belerice were said to improve by lying in water.[21]

(b) Salt water – Seasoning in sea water had been practised from time to time, but opinions differed as regards its efficacy. It was certain, however, that the hygroscopic nature of the salt which impregnates the timber during immersion rendered it objectionable for many purposes. Timber for ship building was sometimes treated before use, but such timber was said never to become perfectly dry, while it corroded iron bolts were driven into it. Nevertheless if a ship had its timber well soaked in salt water it was allowed extra years' duration in its class. That timber so treated was more durable than ordinary timber[22].

(3) Artificial Seasoning

There were many methods of artificially causing the rapid seasoning of wood, but most of them were of little importance in India and often had little to recommend them. A detailed description of them was therefore unnecessary. The Chief of these methods were (a) drying in a current of hot dry air (b) extraction of sap by means of a vaccum, (c) boiling or steaming followed by drying (d) drying over a smoky fire, (e) charring the outside of logs by fire(f) packing wood in common salt, which being highly hygroscopic, extracted the moisture from the wood, this was employed chiefly for finer woods (g) seasoning by electrically, a somewhat recent French inversion whereby the moisture was rapidly driven out of wood by electricity, its place being taken by an antiseptic substance,(h) seasoning during antiseptic treatment.[23]

Defects in Timber

However there are some defects or shakes. Defects may broadly be divided into four classes (1) Defects due to rupture of the tissues (2) Defects due to manner of growth (3) Defects due to presence of healed wounds (4) Defects due to attacks of insects or parasitic plants[24]

Defects due to Rupture of the Tissues[25]

These defects which were technically known as shakes were caused by the separation of fibres along one or more lines, which might be comparatively short or might extend throughout the length of the tree. Shakes were of three kinds (a) Heart-shake (b) Radial Shake(c) Cup shake[26].

Defects due to manner of Growth[27]

(a) Twisted fibre – In this defect the grain of the wood instead of running straight up the tree, twist spirally round the axis. The twist may occur from right to left or from left to right, the direction being constant in some species, but apparently not so in all. Certain species were more liable to twisted fibre than others, for example Hardwickia binata, populers eupharatica, Boswellia serrate, casaurine equisecti folia, and Pinus longifolia were often affected.

(b) Knottiness – Knots were portions of branches which had become enclosed in the wood. In broad-leaved spices these knots did not differ in texture from the wood of the stem to such an extent as was the case in conifers, where the knots were often very hard and tended to become loose and fall out of sown boards.

(c) Wavy wood and burrs – These were more characteristic of some species than of others, , they might greatly increase the value of a wood for ornamental purposes, where strength or fusibility were required, however, they could be regarded only as defects.

(d) Interior bast tissue – The stems of certain species had a peculiar structure. In that the tissues of wood were separated at intervals by tissues of interior bast .This was seen in Bauhinia Vahlii, Millettia, aurculate, Delbergia paniculate, Cocculus laurifolius. Such a defect which sometimes occurred in teak, reduced the size of the squares and planks which could be cut out of the logs.

(e) Contortion produced by the encircling of climbers – The effects produced by the climbers on the shape and development of trees were different according to the manner in which the climbers grow; some like Rosa moschata and Acasic pennata, clinged on by means of their prickles, while others twine round the stems of trees.

Defects due to presence of Healed Wounds[28]

(a) Covered surfaces of pruned branches – However carefully a branch might be pruned, the new wood which grew over the wound never joins completely with the pruned surface, and even if the surface be tarred it was difficult to prevent the ingress of fungi causing not in the wood.

(b) Occluded broken branches – When a branch was broken off a hallow usually formed, in which water settles, this induced rot, which might spread right into the heart of the tree and extended up and down the stem for some distance on either side of the wound. The wound itself took a longer time to heal up than in the case of a pruned branch, so that the damage done by fingers attack during the process of healing was more of extensive owing to its duration.

(c) Rind Gall's(a defect in timber caused by the growth of annual layers of wood over a bruise in the bark). – These were defects in timber due to the inclusion within the wood of old heated wounds which may be caused by a variety of circumstances, such as passing costs, following of trees, barking by deer, bears and other animals, fire etc. During the process of healing rot was very liable to enter the wound and spread inwards, while the new wood, thus producing a defect, which might be discovered only when the timber was sawn up[29].

(4) Defects due to attacks of Insects or Parasitic plants[30]

(a) Insects – The insects which directly affect the commercial value of timber were the wood-borers, whose attacks are at times so destructive as to render wood quite useless as timber. We might divide these insects into two classes according to their modes of attack:

(i) Insects which bore into living trees to lay their eggs or pupate – Against this, successful preventive measures were most difficult to adopt. Some of the most destructive insects of this class known widely were the Larva of the moth Duomitus ceramics, popularly but erroneously called the "bee-hole" of teak (which bored large tunnels in teak trees in Burma and may so reduce the value of the wood as to make it useless except as fuel), stomatium,a longicorn beetle which bored into the heartwood of sandalwood trees and Apate jesuita a bostrichid beetle which bored into casuarina stems.

(ii) Insects which bore into dying or dead trees or into newly-felled or partly-dried timber:- There were many important boring beetles in this class, chiefly bostrichids, seoly tids, and cerambycids. Probably the most destructive Sal borers were Eolesthes holosericea and Hoploceramby & spinicornis which bored tunnels from ½ to ¾ in diameter right into the heart wood in order to pupate. The eggs were laid in the bark, chiefly of newly felled wood. Hence the necessity of barking the wood as soon as the trees were felled was realized.

(b) Parasitic plants- These plants belong chiefly to the order loranthacea, the best known belonging to the genera loranthus and Viscum and they do damage by sending an haustoria's which produced holes in the wood of their host, rendering it useless as timber and reducing its value as fuel. Thus to treat these defects various treatments of the wood was done mainly to strengthen and to make the wood stronger[31]

(3) Chlorides of mercury (corrosive sublimate) was a most effective substance for rendering wood proof against insects and decay. The process was called Kyanising[32.] It was a useful method in dry situation but useless in salt water. It had several disadvantages, the chief of which were its high cost and the violently poisonous nature of the substance affecting iron. The Kyanising of sleeper was tried on Great Indian Penninsula Railway[33] in 1865, but was abandoned, as the sleepers so treated were found to be no cheaper than sleeper made of a teak.[34]

(4) Creosote – This oil was one of the products obtained during the distillation of coal-tar and was cheaper in countries where coal was abundant. The creosote obtained from wood tar would probably be superior to that of coal tar, owing to the great viscosity of the latter and consequent difficulty with which it was driven into the wood. Creosote was superior to metallic salts as an impregnating substance, since it was so thoroughly absorbed in the tissues of wood that it would not wash out.

(5) Saccharine solution (Powells's process)- The substance used in the Powell zing process was a saccharine solution which conveyed into the pores of the wood an arsenical poison.

Many other substances had been tried with varying success, for example, carbolic acid, which was too expensive, lime, ferric ternate, fluorine compounds, dinitro-phenols, etc. Among the various patent antiseptics now on the market might be mentioned Atlas solution, Avenarius Carbolineum, Green oil, Cresoyle, Cresol-calcium, Jodelite Microsol, Solignum, Bellit, Bellitol and others; some of these were known to contain products of distillation of coal tar, and were designed for use in the open tank method. A sulphur process was patented in Germany a few years ago. It consisted in placing the wood to be impregnated in a bath of molten sulphur, and after the liquid sulphur had entered the tissues of the wood the temperature of the bath was reduced below the melting point of sulphur, which hardened the wood. Only the outer layers of the wood become impregnated, so that the method so far had been found suitable only for thin boards.

Another process said to be cheap and effective was the Hassel mann process, in which the sleepers were boiled first in a solution of the sulphates of iron and aluminum, and then in a lime bath under pressure[35]

(2) Methods of Injection[36]

The chief of methods of impregnating wood with antiseptic substances were (1) the hydrostatic method (2) the pneumatic method (3) the open tank method and (4) the brush method.

I. Hydrostatic Injection

By this method, first employed by Boucherie, the antiseptic liquid was driven into the wood by atmospheric pressure alone, the cap being expelled to make room for the liquid. A pressure of one or two atmospheres was sufficient; the necessary pressure being obtained by placing the reservoir of liquid on a platform raised at least 30 feet above the ground and conveying the liquid down a pipe into the timber, in which a hole had been bored to admit the nozzle of the pipe. For this process green timber was necessary, and the bark should be on the log otherwise some of the liquid would escape from its sides, if the log had been kept for a month or two, so that the outer layers were dry, but the inner part of the log was still green, the bark need not be kept on, as the outer layers were sufficiently impervious.

II Pneumatic Injection[37]

Pneumatic injection involved the use of pneumatic force to drive the antiseptic solution into, and in some cases the use of suction to withdraw sap and air from, the timber to be operated on. There were various methods of carrying out the pneumatic injection of timber, the main advantage of which was that impregnation was very complete; on the other hand the necessary plant was as a rule expensive, so that the cost of the work was comparatively high. There were various processes of pneumatic injection, of which the following deserved mention.

(a) Creosoting – For injection by this method the wood was first fully converted, and then tightly stacked on trucks wheeled into large horizontal iron cylinders, which were then tightly closed. The wood was first steamed for an hour at a temperature of 112 ½ ^{o}C after which an air pump was applied which sucked the air and moisture out of the wood by the creation of a vacuum. Creosote was then pumped in until the cylinder is full, and in order to force the liquid into the wood a pressure of about 6 atmospheres was maintained for an hour, more or less, at the end of which time the liquid was withdrawn and the impregnated wood was removed from the cylinder. Sometimes the steaming process was dispensed with, the wood being dried instead.

(b) Burnettising – The salt employed for this process was chloride of zinc. The timber was subjected to a partial vacuum, and then immersed in a 1 to 2 per cent solution of the salt[37].

(c) Gardenerising – The wood was first steamed, dried and again steamed with a chemical, the composition of which was a secret, in order to season it artificially. A strong solution of borax was then forced in pneumatically, and finally the wood was immersed either in chloride of mercury or creosote. During the process the timber was rendered non-inflammable.[38]

(d) Pfister's method – This was a method based on Boucheri's system of introducing antiseptic solutions into timber, but in this case the liquid was forced in by means of a portable force-pump at a pressure up to 20 atmospheres. The pump could be transported to the forest, so that the wood may be injected before removal.

(e) The Ruping process – This was a new process, the theory of which was that only sufficient antiseptic solution should be forced to impregnate the cell-walls of the wood tissue and not permeate the cell cavities; in this way considerably less solution was required than under other pneumatic methods, the cost being thereby reduced.[39]

(3) The Open Tank Method

This method consisted of immersing the wood in an open tank containing a hot antiseptic solution, in some cases leaving it in the solution till the latter cooled down, or the wood might be heated in a hot bath and then quickly transferred to a tank containing a cold solution of the antiseptic. The theory on which the process was based was that the heating of wood produced a vacuum within it, the heated air inside it being expelled, on subsequent cooling the vacuum sucked in the antiseptic solution, capillarity no doubt assisting in the process of absorption. The apparatus used consisted of a tank either placed over a fire or fitted with coils of hot pipes for heating the solution[40].

The Brush Method

This consisted in applying the antiseptic solution to the surface of the wood with a wire burn, the solution being generally heated and two or three coats of solution being applied. Various antiseptics might be employed under this method such as Avenarius carbolineum (heated to $65^{o}-94^{o}$C), Todelite (heated to $82^{o}-94^{o}$C), Solignum (cold or heated to ($160^{o}-180^{o}$F), Microsol, Cresoyle and other substances. The impregnation by this method was not so complete as in the open tank method.[41]

Conclusion

The concept of 'Scientific Forestry' developed the notion of better protection of Indian Forests which in fact gained prominence with the encirclement of Indian forests. This led to the enactment of first Forest Act of 1865 .The colonial forest bureaucracy being totally foreign (mainly educated in European Forest Schools) were unknown of Tropical forest cultures and also of its diverse forest types so the policy of scientific conservation of Indian Forests proved only a myth. In fact the need to better extract the forest resources led to the organization of village forests through the enactment of the Act of 1878. This act recognized the forest spaces of local inhabitants and also their local forest management processes for better extraction. Thus banning grazing, controlling fires, researching forest products surely brought about a new trend in the forestry development of colonial period. Science was no doubt applied but it was applied to innovate and facilitate the treatment processes of Timbers. No attempt was made to improve the Indian Forests as truly that necessitated the involvement of the locals. Community Forest Management process was totally absent and involved on the other hand greater marginalization of the forest dependent people.

Notes and References ;

1. Desiccation means to turn dry. It is an important attribute to the process of deforestation. The term was coined to denounce the pre-colonial environmental system that prevailed in India. For further details see *'Green Imperialism, Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism 1600-1800* by Richard Grove.(Canberra,1996)
2. R.S. Troup – *'Forestry and State Control'*, Revised and enlarged by Editorial Board; FRI & Colleges, Dehra Dun; Printed in India at the FRI Press; published by controller of publications; Delhi; August, 1975 p.1.
3. *Ibid*
4. In 1890, E.C. Buck, the Secretary to the Government of India wrote a letter to the Superintendent of Port Blair and Nicobars, dated 24th January 1890, from Shimla. In this letter he stated that 'it was regretted that little or no information had as yet been obtained with regard to the manner in which this species propagated itself naturally, and the precautions required to ensure its maintenance in the areas felled over'. For further details see *'Forest Administration Report'*; Andamans for 1888-89; Home Department Proceedings Nos.36-37; June 1890; Port Blair (Original)
5. R.S. Troup – *'The Forest Utilization"*; Imperial Forest Service; India; Second Edition; Revised with 26 plates; Calcutta Superintendent Government Printing India, 1913 p.4
6. *Ibid*
7. *Ibid*
8. *Ibid* ;p.8
9. India owed a special debt to the great Forest School of France –'L' Ecote Ntionale des Exux et Forets' for it was here that the majority of her trained forest officers formerly received their professional education. Though few English students were now sent there the reputation of school established around 1820s. The students were initiated in the actual manual work of Sylviculture, as well as of giving them practical lessons in road-making and house building. The theory of various subjects was thoroughly taught in the lecture rooms. There were series of timber samples, the Entomological specimens were mounted in boxes. Forest Botany, Sylviculture and working plans, exploitation, lectures all were part of the curriculum which related much with curriculum of Imperial Forest Research Institute, later on. On the whole the course was more advanced than that for the provincial service at Dehra Dun. The relative importance attached to law and mathematics at Les Barres was remarkable. Seeds were shown in wide inverted tables. Many other interesting exhibits were similar, to those already noticed in the section dealing in Nancy. This was a record of F. Cowley. Brown who belonged to Indian Forest Service (1913) and he expressed his tribute of thanks to Monsieur Dabat, Consciller d'Etat and director General des Eauxat Fore'ts, for the courteous and support offered throughout this tour (29th Dec, 1913). For further details please see *'Report on the Forest Schools of France and on certain French Forests'* by T. Cowly. Brown (Indian forest Service) Simla, published by Government Central branch Press, (1914) pp.3-11
10. C.G. Trevor – *'Review of Indian Forest Management'*; Empire Forestry Journal; Vol-2,; No.2(1923); Common Wealth Forestry Association; p.245.

11. *Ibid* ; p .11.
12. R.S. Troup – *'The Forest Utilization"*; op-cit; pp.10-11
13. Ibid;p.12
14. R.S. Troup – *'A Manual of forest Mensuration'*; Calcutta; Superintendent of Government Printing, India, 1911, p.6.
15. *Ibid* ; pp.6-7.
16. *Ibid* ; p.26
17. *Ibid* ; p.28.
18. *Ibid* ; p.30.
19. R.S. Troup – *'The Forest Utilization"*; op-cit p.35
20. *Ibid* ; p.36.
21. *Ibid* ; p.37
22. *Ibid* ; p.38
23. *Ibid.*
24. *Ibid* ; p.57
25. *Ibid* ; p.58.
26. *Ibid.*
27. *Ibid* ; p.59.
28. *Ibid.*
29. *Ibid* ; p.61
30. *Ibid.*
31. *Ibid* ; p.63.
32. The use of chlorides of mercury (corrosive sublimate) as an antiseptic for timber was patented in 1832 by an Englishman named *Kyan*, and hence the process is known as *Kyanising.* Ibid p-289.
    The sleepers were impregnated to make it last much longer because there were different rates for different sleepers
    For further study please see *'Annual Progress Report on the Forests of the Central Provinces for 1863'* by Government of India 'Department of Revenue and Agriculture' (Forests) Proceedings- Nos. 11/24 April 1865 p.3.
33. *Ibid*
34. *Ibid* ; p .290
35. *Ibid* ; p .291
36. *Ibid* ; p .292.
37. *Ibid.*
38. *Ibid* ; p .293.
39. *Ibid* ; p .294
40. *Ibid* ; p .296
41. *Ibid* ; p .297.