

# **Teak (*Tectona grandis*) Plantation towards Carbon Sequestration and Climate Change Mitigation in district Balaghat, Madhya Pradesh, India**

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**ABSTRACT:** Industrial and population growth has resultant mining and mineral excavation. This further altered the land use and ultimately resultant air, water and land pollution. Due to industrialization and human inference carbon emission in the atmosphere has increased tremendously resultant green gas damaging ozone layer of the earth which is matter of concern. Forest is very much effective sink of carbon which absorb substantial amount of carbon dioxide converts into fruitful bio-product like timber, food, fibre and fruits for human consumption. In the present article the teak future scope and potentiality for carbon sequestration and importance in climate change mitigation has been discussed in brief. In Balaghat district of Madhya Pradesh forest cover have majority of teak (*Tectona grandis*) plantation which has significant contribution in carbon sequestration and have more potentiality to help in climate change mitigation has been briefly discussed. Some issues of major interest like agronomical practices for sustainable growth, intercultural operation issues, soil amendments, use of agro-forestry techniques, mixing of other tree species for teak plantation has prime benefit to carbon sequestration and climate change management were covered.

**KEYWORDS:** Teak, Carbon sequestration, Soil, Agro-forestry, Agronomical practices and climate changes.

## **I. INTRODUCTION**

Dhanbad is famous for coal mining in India, surrounded by major power plants and coal washeries supported power generation with major industrialization in this eastern zone. Due to underground and opencast coal mining the land use changes the original topography with land degradation taken place in greater ways. Cumulative effects of mining and old quarries resultant air, noise, surface and ground water with land pollution reduced the vegetation and agriculture in this area. The utilization of coal in power plant generates flyash as waste product resultant air water and land pollution. This can be accessed through environmental impact assessment and environmental management plan with environmental monitoring will help the industries to evaluate the extent of environmental damage and improvement matrix. Overall this has resultant in the major changes in socio-economic. But the quality of life has been affected in this area with all other developments (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 45, 66, 69, 78, 86, 87, 88, 100, 102, 105, 106, 107, 108, 109, 110, 122, 123, 124, 129, 131, 132, 140, 142 and 146).

The effect of mining through modeling and simulation were assessed for effective environmental management to achieve sustainable development (43, 47, 49, 71, 72, 73, 74 and 75). The mining generates dust which affects on the growth and development of the plant species (134, 136, 137, 138 and 146). The most effective method to control green house gas through carbon sequestration and mitigation measures (148, 152).

Flora and fauna drastically affected due to many environmental pressure. This leads to changes in the availability of terrestrial and aquatic flora and fauna with avian species. In this connection a study has been undertaken to investigate

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the availability of different algal biodiversity which is a very good indicator of different type of environment. Algae have different potentiality for the sustainable development of this disturbed area (111, 113, 114, 115, 116, 118, 119, 120, 127, 133, 134, 141, 145 and 147).

Water environment is most concern in the mining areas. For the reclamation of wastewater with land, bio-approach is effective one to restore many things.

Through this approach solve the food and environmental problems in this area (31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 46, 48, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 65, 67, 79, 80, 81, 82, 83, 84, 85, 90, 91, 92, 93, 94, 96, 104, 135).

The bio-treatment of polluted water vis-a-vis socioeconomic development had found effective in this area. Bio-purification also include using algae (62, 63, 64, 68, 70, 76, 77, 89, 95, 97, 98, 99, 101, 103, 112, 117, 121, 125, 126, 128, 130, 136, 137, 138 and 139).

The task of finding, developing and maintaining suitable water supplies has not been limited to modern times. It has had to be faced wherever large numbers of people have crowded together in small spaces; and therefore the popular indifference towards safe, clean water has prevailed. Other means of pollution abatement in industrial areas may be through roof top garden which are more affective (153, 154, 156).

Planning for the maximum development of our water resources for long time benefit of all our people when properly conceived, can bind together individual and the community, farmer and urbanate as few other conservation activities can do (143). Ponds are valuable water systems and intensively used for production of drinking water, for fisheries and bathing with washing of clothes. The ecological nature of many ponds, however have desecrated, mainly as a consequence of eutrophication (144). Algal diversity in ponds plays an important role in their conservation (149, 150, 151, 155).

Carbon management in forest plantations will probably be the single most important agenda of the first half of the 21st century in India in the context of the greenhouse effect and mitigation of global climatic changes. Today teak (*Tectona grandis*) is widely planted in most of the district of Madhya Pradesh and having forest as an exotic species. This teak based global sink would certainly increase because during the past 20 years most supplies of teak wood from natural forests have dwindled and increased interest has developed in the establishment of teak forest plantations (Fig.1).



Figure no.1: Teak plantation area.

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Teak has the highest capacity for carbon sequestration among trees in India (157). Carbon dioxide traps heat and is the main villain insofar as global warming is concerned. Carbon sequestration is the process by which carbon dioxide is captured from the atmosphere by trees for long-term storage and in its lifetime, a teak tree absorbs 3.70 lakh tonnes of carbon dioxide from the atmosphere (158). This paper describes the teak plantation botanical features, agronomical details for its sustainable existence in district Balaghat, Madhya Pradesh. The agro-climatic suitability for teak plantations has been shown in **Fig.2**:



Figure no. 2. Showing different Agro-climatic zones of Madhya Pradesh.

The present paper stresses the teak plantation and forest in Madhya Pradesh agro-climatic zone Chhatisgarh plain, Balaghat (**Fig.3**). Balaghat District is located in the southern part of Jabalpur Division. It occupies the south eastern portion of the Satpura Range and the upper valley of the Wainganga River. The district extends from 21°19' to 22°24' north latitude and 79°31' to 81°3' east longitude. The total area of the district is 9,245 km<sup>2</sup> (**Fig.4**).



Figure no.3: District Balaghat, Madhya Pradesh at a glance



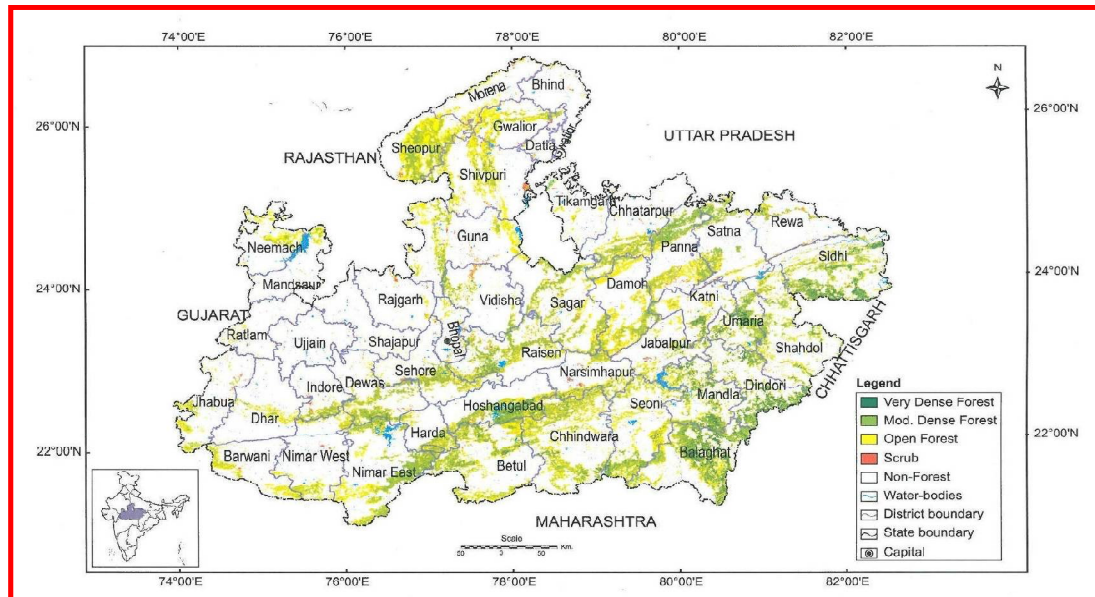


Figure no.4: Type of forest in Madhya Pradesh

## II. BOTANICAL FEATURES

Teak is a tropical hardwood tree of species *Tectona grandis*. The species is placed in the family Lamiaceae. *Tectona grandis* is a large, deciduous tree that is dominant in mixed hardwood forests. It has small, fragrant white flowers and papery leaves that are often hairy on the lower surface. It is sometimes known as the "Burmese Teak". Teak wood has a leather-like smell when it is freshly milled. Teak timber is particularly valued for its durability and water resistance, and is used for boat building, exterior construction, veneer, furniture, carving, turnings, and other small wood projects [159].

*Tectona grandis* is native to south and south east Asia, mainly India, Indonesia, Malaysia, Thailand and Burma, but is naturalized and cultivated in many countries in Africa and the Caribbean. Burma accounts for nearly one third of the world's total teak production.

Teak is a large, deciduous tree up to 40 m (131 ft) tall with gray to grayish brown branches. Leaves are ovate-elliptic to ovate, 15–45 cm (5.9–17.7 in) long by 8–23 cm (3.1–9.1 in) wide, and are held on robust petioles that are 2–4 cm (0.8–1.6 in) long. Leaf margins are entire [160].

Fragrant white flowers are borne on 25–40 cm (10–16 in) long by 30 cm (12 in) wide panicles from June to August. The corolla tube is 2.5–3 mm long with 2 mm wide obtuse lobes. *Tectona grandis* sets fruit from September to December; fruits are globose and 1.2–1.8 cm in diameter [160]. Flowers are weakly protandrous in that the anthers precede the stigma in maturity and pollen is shed within a few hours of the flower opening [161]. The flowers are primarily entomophilous (insect-pollinated), but can occasionally be anemophilous (wind-pollinated) [162]. A 1996 study found that in its native range in Thailand, the major pollinator were species in the *Ceratina* genus of bees [161].

- heartwood is brownish red in color. It becomes darker with getting older. Sometimes there are dark patches on it. There is a strange scent in newly cut wood.
- sapwood is whitish to pale yellowish brown in color. It can easily separate from heartwood.
- wood texture is hard and ring porous.
- density is 720 kg/meter cube.

*Tectona grandis* is one of three species in the genus *Tectona*. The other two species, *T. hamiltoniana* and *T. philippinensis*, are endemics with relatively small native distributions in Myanmar and the Philippines, respectively [163]. *Tectona grandis* is native to India, Indonesia, Myanmar, northern Thailand, and northwestern Laos [160, 161].

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*Tectona grandis* is found in a variety of habitats and climatic conditions from arid areas with only 500 mm of rain per year to very moist forests with up to 5,000 mm of rain per year. Typically, though, the annual rainfall in areas where teak grows averages 1,250-1,650 mm with a 3-5 month dry season [164].

*Tectona grandis* was first formally described by Carl Linnaeus the Younger in his 1782 work Supplementum Plantarum [165]. In 1975, Harold Norman Moldenke published new descriptions of four forms of this species in the journal Phytologia. Moldenke described each form as varying slightly from the type specimen: *T. grandis* f. *canescens* is distinguished from the type material by being densely canescent, or covered in hairs, on the underside of the leaf, *T. grandis* f. *pilosula* is distinct from the type material in the varying morphology of the leaf veins, *T. grandis* f. *punctata* is only hairy on the larger veins on the underside of the leaf, and *T. grandis* f. *tomentella* is noted for its dense yellowish tomentose hairs on the lower surface of the leaf [166, 167]. Teak also holds the medicinal value. The bark is bitter tonic and is considered useful in fever. It is also useful in headache and stomach problems. Digestion may be enhanced by the teak wood or bark. It is used in the furniture making, boat decks and for indoor flooring. It is widely used to make the doors and house windows. It is resistant to the attack of termites. Its wood contains scented oil which is the repellent to insects. The leaves yield the dye which is used to colour the clothes and edible. Teak is probably the best protected commercial species in the world [168].

### III. AGRONOMICAL FEATURES

Sagwan (Teak) is tropical hardwood species and belong to family of Lamiaceae. It is most valuable and high price timber crop of India. It is deciduous tall tree upto 40m tall with gray to grayish brown branches. In india, sagwan plantation take place in 1842 and Chatu Menon from Kerala state is known as Father of Indian Teak plantation. It is most important hardwood and use for making of furniture, plywoods, all types of construction pole, ship building etc. The most suitable temperature required is 10-45 0C for sowing, harvesting and its growth period. For good growth, it required well drained, deep and fertile soil. pH of soil should be 6.5 or above. Growth of plant get affected when pH is less 6.5. Konni Teak, West African teak, Godhavari Teak, South and Central American Teak, Nilambur or Malabar Teak.

Land is ploughed for two three times and soil is brought to fine tilth and also level soil to avoid water stagnation in field. For seedling transplantation, digging pits of 45cm x 45cm x 45cm and application of mixed well decomposed cowdung along with insecticides in each pit. Seeds are sown in nursery beds and seedlings of 12-15months are used for stumps preparation for planting with clonal propagation done through grafting, rooted stem cutting and micro propagation. Plantation by using pre sprouted stumps and monsoon is best season for teak plantation.

For plantation, spacing of 2m x 2m or 2.5m x 2.5m or 3m x 3m, whereas, intercrop is taken spacing of 4m x 4m or 5m x 5m can be used. For planting sagwan pre sprouted stumps, pits of size digged 45cm x 45cm x 45cm and filled pit with soil and well decomposed cow dung. Sowing is done by Line Sowing, Broadcasting or Transplanting method approximately 1500-1800 clones required for planting in one acre area. Fruits of teak plant cover with thick and hard meso-carp therefore before sowing in nursery various pre-treatments are done on seeds of sagwan to increased germination percentage. Traditional simple method of pre-treatment is alternate soaking and drying of fruits. In this method seeds are soaked in water for 12 hours then dry in sun for 12 hour. This process of wetting and drying is repeated for 10-14days. Acid method and pit methods are other methods of pre-treatment. In August and September month of every year apply N:P:K (15:15:15) @50gm per plant for first three years.

During first three years establishment, intense weeding is necessary to keep weed free. Weeding operations is carried out on regular basis followed by first year, three weeding operation and in second year two weeding operations and one weeding operation in third year of plantation. In monsoon month no irrigations are required and application of irrigation in hot or summer month or during stress periods. Irrigation during stress period improve yield to great extent. Excess irrigation would leads to development of water blisters and spread fungi. Teak defoliator, skeletonize are serious pest of teak and they damaged tree to greater extent. For controlling the pest, spraying of quinalphos@300ml/150 ltr of water is done. Pink disease, powdery mildew and root rot are major disease of teak plant. This is being controlled by spraying of M-45@400gm per acre. When trees are approaches to harvesting stage, marking and submission of report to chief regional Forestry officer. After getting permission harvesting is planned. Teak farming is

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highly profitable farming as it hand have greater demand in India as well as abroad. In 14years each teak tree yield about 10-15 cubic feet wood [169, 170]

## IV. CARBON SEQUESTRATION

Teak has the highest capacity for carbon sequestration among trees in India. This is the finding of a study conducted by the Gujarat Ecological Education and Research (GEER) to prepare a hierarchy of local trees in India that can reduce the carbon dioxide content of the atmosphere. Carbon dioxide traps heat and is the main villain insofar as global warming is concerned. Carbon sequestration is the process by which carbon dioxide is captured from the atmosphere by trees for long-term storage. In its lifetime, a teak tree with a girth of 10-30 cm can absorb 3.70 lakh tonnes of carbon dioxide from the atmosphere. Teak's is common name in India is sagwaan while its botanical name is *Tectona Grandis*. It is followed by Neelgiri tree which absorbs 2.46 lakh tonnes of carbon dioxide and the Neem tree with a carbon sequestration capacity of 1.45 lakh tonnes in its lifetime. A total of 33.66 million tonnes of carbon dioxide had been sequestered by trees in non-forest areas of Gujarat. There are over 30 crore trees in non-forest areas in the state [157]

Carbon storage potential of teak plantation was estimated by studying plantations in Nilambur undergoing prescribed thinning schedules. Nilambur in Kerala State has the reputation of establishing the first teak plantation in India. The area has a humid tropical climate with around 300 cm annual rainfall received from the two monsoons. The soil is well drained coarse textured oxisol with high content of sesquioxides. An average teak tree at Nilambur was found to attain a height of 6.93 m and dbh of 6.3 cm at 5 year which was seen to increase to 22.83 m and 45.85 cm, respectively at the final felling stage of 50 years. Biomass was found to increase from 65.38 kg tree<sup>-1</sup> at the first stage to 1085.70 kg tree<sup>-1</sup> at the final stage of felling. Significant increase in growth and biomass production was noted after 30th year of plantation. Carbon sequestration in various compartments of teak followed the pattern bole > branch > root > bark in the initial stages and bole > root > branch > bark in the latter stages. Carbon sequestration increased with age and at 50 years 332.88 kg tree<sup>-1</sup> carbon was found to be stored in bole, 60.63 in branch, 80.06 in root and 26.57 kg tree<sup>-1</sup> in bark compartment giving a total of 508.14 kg tree<sup>-1</sup> of carbon [158].

## V. CLIMATE CHANGE MITIGATIONS

Trees are the dominant structural element in natural forests and other artificial forest like plantation, agro-forests, woodlands, botanical gardens which intercepting much of the radiant sunlight, dominating photosynthesis processes and carbon flows and comprising a large proportion of the biomass [171, 172]. Trees and forests have an essential and central role to limit rises in atmospheric carbon and slow down the climatic change through sequestration and storage of atmospheric carbon. Mature, new and planted forests can sequester substantial amounts of carbon. Moreover, fast growing planted forests sequester vast amounts of carbon. Therefore, the forest carbon sink is considered as a useful option for mitigating climate change [173].

The United Nations Climate Change Conference (UFCCC) made seven decisions relating to forests in 2013 and confirmed the important role played by forests in offsetting industrial emission of green house gases. Terrestrial ecosystem carbon sequestration can reduce the rate of build up of greenhouse gases in the atmosphere and therefore can contributes to a better human adaption to current and future environmental changes. Forest ecosystem plays a significant role in the climate change system. Trees store carbon throughout their life and release it through decomposition. Since forests are important carbon sinks and source, assessing forest carbon budgets has received much attention in recent years [174, 175 and 176].

## VI. CONCLUSION

Teak plantation have very good carbon sequestration potentiality depends upon the species, plantation techniques, agronomical practices followed for the maintenance with after care. Moreover, teak plants also help in climate change mitigation measures through absorbing many green gaseous converting them and fixing in biomass and giving back oxygen to atmosphere. Apart from this have great potentiality in enriching forest floor to support the growth and biomass.

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## REFERENCES

- [1] R. Abidi, B.K.Tewary, T.B.Singh, Kumar Nikhil and N.C.Saxena (1992), "Reclamation of Surface Mining Degraded Land – A New Strategy", in Fourth National Seminar on Surface Mining at I.S.M Dhanbad (3-4<sup>th</sup> November, 1992). A MMGMI Publication, pp-206-212.
- [2] Kumar Nikhil, S.Gupta, B.K.Tewary and B.B.Dhar (1993), "Impact of Iron Ore Mining on Agricultural Land", in National Seminar on Eco-friendly Approaches in the Management of Pest, Diseases and Industrial Effluents (11-12<sup>th</sup> November, 1993) at Chandra Sekhar Azad University of Agriculture and Technology, Kanpur (U.P).
- [3] R.S.Singh, B.K.Tewary, S.K.Chaulya, Kumar Nikhil and B.B.Dhar (1994), "Evaluation of Tree Species Performance on a Coal Mine Overburden Dumps", in Jharia Coalfield Problems and Prospects, MGMI, Dhanbad Branch Publication Seminar on World Environmental Day at BCCL Dhanbad (5<sup>th</sup> June, 1994).
- [4] Kumar Nikhil, B.K.Tewary and B.B.Dhar (1994), "Koyalanchal ke bhumi ke punharudhar ke ley – kawak ki aham bhumika" in Hindi Seminar on Damodar Ghati ka Paryavaran Sanrakchan at CMRI, Dhanbad.
- [5] Kumar Nikhil, B.K.Tewary and B.B.Dhar (1994), "Jharia koyalanchal ke paryavaran sudhar may samajik aivam krishi waniki ka yogdan" in Hindi Seminar on Jharia Satabdi (1894-1994) at CMRI Dhanbad.
- [6] T.B.Singh, Kumar Nikhil, R.S.Singh and B.K.Tewary (1995), "Prospects of Minewastes Utilization", in All India Symposium on Converting Wastes into Wealth [ Organized by B.I.T Sindri& Institute of Engineers (I), Dhanbad Local Centre] at CMRI , Dhanbad on September 15-16, 1995.
- [7] Kumar Nikhil, T.B.Singh, R.S.Singh and B.K.Tewary (1995), "Prospects of Agrowastes for land reclamation", in All India Symposium on Converting Wastes into Wealth [Organized by B.I.T Sindri& Institute of Engineers (I), Dhanbad Local Centre] at CMRI , Dhanbad on September 15-16, 1995.
- [8] B.K.Tewary, T.B.Singh, S.K.Chaulya, Kumar Nikhil and B.B.Dhar (1995), "Land Reclamation Practices in India", in First World Mining Environment Congress at New Delhi on 11-14 December, 1995.
- [9] Kumar Nikhil, E. Sarnathan, V.J.Loveson, R.S.Singh, B.K.Tewary (1995), "Watershed Management for Sustainable Development – A case study", in World Environment Day for watershed Management on 5<sup>th</sup> June, 1995 at CMRI Dhanbad
- [10] Kumar Nikhil, T.B.Singh and B.K.Tewary (1996), "Audhogicaran ka vikas, paryavaran sanrakchan aivam ped podhoo ka yogdan", in Jharkand Anchal Ke Van Sampada – Atit aivam Vartaman at CMRI Dhanbad on 5<sup>th</sup> June, 2016.
- [11] B.K.Tewary, Kumar Nikhil, R.S.Singh, T.B.Singh and B.B.Dhar (1996), "Environmental Management of Flyash", in course on stabilization and filling issues in Raniganj and Barakar measures seam for ground control 23-27<sup>th</sup> December, 1996 by HRD, CMRI, Dhanbad.
- [12] Kumar Nikhil (1997), "Reclamation of O.B.Dump" in Training Programme in Environmental Pollution for DVC Doctor on 3-7<sup>th</sup> March, 1997 at CMRI, Dhanbad.
- [13] Kumar Nikhil, T.B.Singh and T.N.Singh (1997), "Audogikaran ka vikas aivam ped padho ka yogdan" in Hindi Seminar on Paryavaran awam sanrakchan at CBRI, Roorkee on 5<sup>th</sup> June, 1997.
- [14] Kumar Nikhil (1997), "Wasteland Management", Training Course on the Recent Advancement in the Environmental Management of Mining Areas for the Coal India Executives in CMRI Dhanbad on 3-4<sup>th</sup> November, 1997.
- [15] Kumar Nikhil, T.B.Singh and T.N.Singh (1997), " Audogikaran ka vikas aivam ped padho ka yogdan" in Hindi Seminar on Paryavaran awam sanrakchan at CBRI, Roorkee on 5<sup>th</sup> June, 1997.
- [16] P.K.Singh, Kumar Nikhil, V.J.Loveson and T.N.Singh (1998), "Khanan dwara chatigrast bhumi ka Prahitasisipunurudhar – ek paricharcha" in Hindi Seminar on Khanan dwara chatigrast parayavaran ka Prahitasisipunurudhar on 4<sup>th</sup> April, 1998 at CMRI Dhanbad.
- [17] Kumar Nikhil, V.J.Loveson and T.N.Singh (1998), "Effect of Bulk Density of the OB Dump on the growth & biomass of perennial grasses", in 7<sup>th</sup> National Symposium on Environment on 5-7<sup>th</sup> February, 1998 at ISM, Dhanbad.
- [18] Kumar Nikhil (1998), "Impact of Mining on Soil Quality and its Mitigative Measures" in Training programme for Central Pollution Control Board Personals funded by World Bank Aided Course on 16-20<sup>th</sup> November, 1998 at CMRI Dhanbad.
- [19] Kumar Nikhil, V.J.Loveson and T.N.Singh (1998), "Change in Nutrient Status of coal overburden dump top material after vegetation – An experimental study" in International Conference on Environment and Agriculture by International Ecological Society at Kathmandu Nepal on 1-3<sup>rd</sup> November, 1998.
- [20] V.J.Loveson, Kumar Nikhil and T.N.Singh (1998), "Evaluation of Croplands around a part of fragile hilly tract of lower Himalaya using Remote Sensing and GIS" in International Conference on Environment and Agriculture by International Ecological Society at Kathmandu Nepal 1-3<sup>rd</sup> November, 1998.
- [21] Kumar Nikhil and V.J.Loveson (1998), "Impact of cropping pattern and pesticide control in watershed eco-development and management", International Conference on Pest & Pesticides Management for Sustainable Agriculture on 11-13<sup>rd</sup> December, 1998 at C.S.Azad University of Agriculture & Technology, Kanpur (U.P).
- [22] P.K.Singh, Kumar Nikhil, V.J.Loveson and T.N.Singh (1998), "Rapid Industrialization in Chotanagpur region and its impact on environment – A case study in Dhanbad District", in XI NCME "Environmental Status of Mining Areas" on 5-6<sup>th</sup> June, 1998 at CMRI, Dhanbad.
- [23] Kumar Nikhil (1999), " A field experience with bioreclamation of coal overburden dump" in International Conference on Clean Coal Initiatives on 22-24<sup>th</sup> January, 1999 at Laa Meridian Hotel, New Delhi.
- [24] M.Ahmed, M.K. Chakraborty& Kumar Nikhil (2000), "Impact of Mining on Socio-cultural and Economic Dimensions" presented in the National Seminar on the Mining & Environment at Aligarh Muslim University on 11-13, April, 2000.
- [25] Kumar Nikhil and M. Ahmed (2000), "Management Of Irrigation Efficiency In Coal Mining Areas of District Dhanbad" presented in the National Seminar on the Mining & Environment at Aligarh Muslim University on 11-13, April, 2000.
- [26] Kumar Nikhil (2001), "Reclamation Economics in Rehabilitation of Limestone Mining" Executive Development Aspects of Mining & Environment held at HRD, CMRI, Dhanbad on 21<sup>st</sup> November, 2001.



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(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 9, September 2017

- [27] Kumar Nikhil, V.J.Loveson, A.K.Singh and Prof.R.Venugopal (2001), "Bio-rehabilitation of Reject Dump around Coal Washery Area – A Conceptual Approach", International on Challenges in Coal & Mineral Beneficiation, Organized by ISM, Dhanbad during 7-8<sup>th</sup> December 2001.
- [28] Kumar Nikhil (2001) "Situation and Strategies for the Utilization of Flyash in Rural Areas", *International Journal of Industrial Pollution Control*, Vol.17 (2)2001: 307-312.
- [29] Kumar Nikhil (2001) "Bio-fertilizers for the re-vegetation of coal overburden dumps top materials", *Asian Jr. of Microbiology, Biotech & Env. Sc.* Vol.3. (4) 2001: 301-305.
- [30] Kumar Nikhil (2002) "Reclamation Economics in Rehabilitation of Limestone Mining Areas", *International Jr. of Industrial Pollution Control* 18 (1) 2002: 21-28.
- [31] Kumar Nikhil, M.Sundararajan, T.B.Singh, A.K.Singh (2002) "Environmental Scenario for small medium scale mining industries in India - Changes & Challenges Ahead", *National Seminar on Policies, Statutes & Legislation in Small and Medium Mines (POSTALE)* CMRI Dhanbad, 5-6<sup>th</sup> January, 2002 : 111-116.
- [32] D.K.Mitra and Kumar Nikhil (2002) "Health Situation of Workers in Mining Industry", *National Symposium on Sustainable Mining Technology: Present and Future*, Anna University Chennai-600025, 14<sup>th</sup>-15<sup>th</sup> March, 2002: 28-32.
- [33] M.Sundararajan, G.K.Banerjee, Kumar Nikhil and D.D.Misra (2002) "Air Quality Dispersion Scenario at Noamundi Iron Ore Mine through Mathematical Modeling and Computer Simulation - A Case Study", *National Symposium on Sustainable Mining Technology: Present and Future*, Anna University Chennai-600025, 14<sup>th</sup>-15<sup>th</sup> March, 2002: 322-331.
- [34] Kumar Nikhil, M.Sundararajan, T.B.Singh and N.C.Saxena (2002) "Water Hyacinth - Boon or Bane for Jharia Coalfield", *National Symposium on Sustainable Mining Technology: Present and Future*, Anna University Chennai-600025, 14<sup>th</sup>-15<sup>th</sup> March, 2002:347-356.
- [35] Kumar Nikhil, M. Sundararajan&D.D.Misra (2002) "Integrated Water Resource Management for the Jharkhand State: A Conceptual Approach", *International Conference on Water and Wastewater: Perspectives of Developing Countries (WAPDEC 2002)*, IIT Delhi -110016, 10<sup>th</sup>-13<sup>th</sup>, December, 2002.
- [36] M. Sundararajan, Kumar Nikhil, A.Khalkho, T.K.Mondal (2002) "Transport Modeling on Ground Water Contamination in and around mining and allied industrial zones - A Case Study", *International Conference on Water and Wastewater: Perspectives of Developing Countries (WAPDEC 2002)*, IIT New Delhi-110016, 10<sup>th</sup>-13<sup>th</sup>, December, 2002.
- [37] Kumar Nikhil, Puran Kishore Singh and C. Bandhopadhyay (2002) "Jharkhand meyJalPrabandhan", *National Seminar on KrishiElectronikiUpkaranVinyash*, CSIO, Chandigarh – 160030, 23<sup>rd</sup>-24<sup>th</sup> April, 2002.
- [38] Kumar Nikhil, M.Sundararajan and Puran Kishore Singh (2002) "Jharkhand keeKrishimeyUrja key NayeyStroth", *National Seminar on KrishiElectronikiUpkaranVinyash*, CSIO, Chandigarh – 160030, 23<sup>rd</sup>-24<sup>th</sup> April, 2002.
- [39] Kumar Nikhil, V. J. Loveson & M. Sundararajan (2002) "Jharkhand mey Suchna Prodhogiki kaa gramin awam krishi Vikas mey Prayog – aik paricharcha", *National Seminar on Krishi Electroniki Upkaran Vinyash*, CSIO, Chandigarh – 160030, 23<sup>rd</sup>-24<sup>th</sup> April, 2002.
- [40] Kumar Nikhil (2002) "Flyash for Better Composting", *International Journal of Ecology, Environment and Conservation*, Vol.8(2)2002: 331-333.
- [41] Kumar Nikhil (2003) "Use of Mycorrhizae for Mined Land Revegetation", *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*, Vol.4(4)2003: 495-498.
- [42] Kumar Nikhil (2003), "Use of Tobacco Waste for the Betterment of Brinjal Crop", *Recent Advances in Water Pollution Studies*, Ed. Dr. R.K.Trivedy, EM International, pp.189-192.
- [43] J.Mariyosh, S.Rufus David, M.Sundararajan and Kumar Nikhil (2003), "Establishing Indian Calendar and Cronology Using Radiometric Dating Methods- Is Reliable", *National Seminar on Indian Calendar & Chronology*, Vigyan Bharati, Dhanbad, 9-10<sup>th</sup> Aug, 2003.
- [44] Kumar Nikhil (2003), "Nutrient Status of Coal Overburden Dump Top Material After vegetation - An Experimental Study", *International Journal of Ecology, Environment and Conservation*, Vol.8(4)2003: 353-360.
- [45] Kumar Nikhil (2003) "Wasteland Rehabilitation around Coal Washery Areas through Bio-remedial Measures", *International Journal of Pollution Research*, Vol.21(3)2003: 249-251.
- [46] Kumar Nikhil (2003) "Growth Response in Crops Raised in Flyash amended soil", *International Journal of Pollution Research*, Vol.21(4)2003: 409-416.
- [47] M.Sundararajan, B.R.Panduranga, Kumar Nikhil, S.Rufus David and J.Mariyosh (2003) "A View on the Calendar and Cronology of Ancient India in the Light of Scientific, Religious and Archaeological Discoveries", *National Seminar on Indian Calendar & Chronology*, VigyanBharati, Dhanbad, 9-10<sup>th</sup> Aug, 2003.
- [48] Kumar Nikhil, M.Sundararajan, N.C.Saxena and D.D.Misra (2003) "Heavy Metal Status in the Species Grown on Coal Overburden Dump- A Case Study", *National Seminar on Status of Environmental Management in Mining Industry(SEMMI-2003)*, Banaras Hindu University, Varanasi- 221005 (UP) 17<sup>th</sup>-18<sup>th</sup>, January, 2003.
- [49] M. Sundararajan, G.K.Banerjee, Kumar Nikhil, D. Vetrisevram, M.K.Chakroborty (2003) "Computerized Air Quality Dispersion Modeling for the Prediction of SPM in and around Opencast Coal Mining- A Case Study", *National Seminar on Status of Environmental Management in Mining Industry(SEMMI-2003)*, Banaras Hindu University, Varanasi- 221005 (UP) 17<sup>th</sup>-18<sup>th</sup>, January, 2003.
- [50] Kumar Nikhil (2003) "Suitable Fillers for the Overburden Dump Plantation Pits to Achieve Better and Economical Re-vegetation", *International Journal of Ecology, Environment and Conservation*, Vol.9(1)2003:
- [51] Kumar Nikhil and M. Sundararajan (2003) Natural Resource Management for the Sustainable Development in Jharkhand State – A Technological Approach, *All India Seminar on Resource Management through Technology for Development of Jharkhand*, MECON, Ranchi-834002, Jharkhand, 22<sup>nd</sup> June, 2003.
- [52] M. Sundararajan and Kumar Nikhil (2003), "Optimized Rain Water Harvesting and Utilization Techniques in Elevated Terrain Regions of Micro-watershed Area through Topographical Water Resource Modeling", *All India Seminar on Resource Management through Technology for Development of Jharkhand*, MECON, Ranchi-834002, Jharkhand, 22nd June, 2003.



## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 9, September 2017

- [53] Kumar Nikhil and Asha Gupta (2004) "Jharkhand kiJariButiyoseyKitnashakDawaiya: AwashktayaiavaimSambhanayai", *Third AkhilBhartiyaVigyanSamelan*, NPL, New Delhi, 19<sup>th</sup>-21<sup>st</sup> February, 2004.
- [54] Kumar Nikhil, M.Sundararajan, Kumar Birendra and Asha Gupta (2004) "Vetiver Grass Technology: An Economical Bio-Reclamation Approach for the Coal Overburden Dump", *National Seminar on Environmental Engineering with special emphasis on Mining Environment*, ISM, Dhanbad, Jharkhand, 19-20<sup>th</sup> March, 2004. (Published in the Journal of the Institution of Public Health Engineers, India, Special Issue, Kolkata)
- [55] Kumar Nikhil (2004) Water Hycinth: A Green Tool for the Sustainable Development of Coalfield, ed. Trivedy, R.K, "Biotechnological Application in Environmental Management": 2-21.
- [56] Kumar Nikhil (2004), "Legumes: Importance in the Re-vegetation of Overburden Dumps" ed. Trivedy, R.K, "Biotechnological Application in Environmental Management": 159-173.
- [57] Kumar Nikhil (2004) "Effect of Heavy Metals on Planted Species Root Growth and Biomass over Coal overburden dump", *International Journal of Industrial Pollution Control* Vol.20(1)2004: 101-109.
- [58] Kumar Nikhil (2004) "Reclamation Bond", *International Journal of Industrial Pollution Control*, Vol.20(1)2004: 97-100.
- [59] Kumar Nikhil (2004) "Accumulating Factor of Heavy Metals in Planted Species over coal overburden dump", *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*, Vol.6(4)2004:
- [60] Kumar Nikhil (2004) "Importance of Tillage Practices in the Re-vegetation of overburden dump", *International Journal of Ecology, Environment and Conservation*, Vol.10(3)2004: 283-286.
- [61] Kumar Nikhil (2004) "Vetiver Grass for the Bio-reclamation of Coal Overburden Dumps" *International Journal of Ecology, Environment and Conservation*, Vol.10(4)2004: 1-14.
- [62] Kumar Nikhil, M.Sundararajan, M.Ahmad, M.S.Alam and Asha Gupta (2004) "Impact of Pesticides and Agricultural Wastes on the Environment of Mining Areas", *National Seminar on Pollution in Urban Industrial Environment (NSPUIE-2004)*, RRL, Bhubaneswar-751013, 2<sup>nd</sup>-3<sup>rd</sup> December, 2004.
- [63] Kumar Nikhil, M.Sundararajan, Mobin Ahmad, M.K.Chakraborty and Asha Gupta (2004) "Optimization of Bio-remedial Measures for Coal Mining Contaminated Soil with Agronomical Practices- A Conceptual Approach", *International Conference on Soil and Groundwater contamination: Risk Assessment and Remedial Measures*, NGRI, Hyderabad-500007, 8<sup>th</sup>-11<sup>th</sup> December, 2004.
- [64] Kumar Nikhil (2005) "Accumulation Factor of Heavy Metals in Planted Species over Coal Overburden Dump", *Asian Journal of Microbiology, Biotechnology and Environmental Science*, Vol.7 (1):2005:1-5.
- [65] Kumar Nikhil (2005) "Ecological Management of Polluted Water due to Mining and allied Industries", *International Jr. of Industrial Pollution Control*, Vol.21 (2) 2005, pp.255-271.
- [66] Kumar Nikhil (2005) "Bio-treatment of Polluted Water vis-a-vis Socio-Economic Development in Coal Mining Area", *International Jr. of Industrial Pollution Control*, Vol.21(2) 2005, pp.229-236.
- [67] Kumar Nikhil, M.S.Alam and Asha Gupta (2005), "Agro-Technological Measures For The Cultivation Of Sinduri (Bixa Orellana L.) And It's Economical Uses, in National Seminar on Cultivation of Aromatic Plants in Bihar, Department of Botany B.M.D. College, Dayalpur Bidupur Railway Station, Vaishali, B.R.A.B.U., BIHAR-84450 on 24-5<sup>th</sup> March, 2005.
- [68] M.S.Alam, Kumar Nikhil, M.Sundararajan, Mobin Ahmad and Asha Gupta (2005) Socio-economic Development through optimum utilization of mineral processing wastes, *International Seminar on Mineral Processing Technology (MPT-2005) at Deptt. Of Minerals & Fuel Egg. Indian School of Mines, Dhanbad-826004 on 6-8<sup>th</sup> Jan.2005.*
- [69] Kumar Nikhil and Asha Gupta (2005) A Conceptual Approach for the Restoration of Wastelands in Jharia Coalfield, *Conference on Technological Advancements and Environmental Challenges in Mining and Allied Industries in the 21<sup>st</sup> Century (TECMAC-2005) at Deptt. Of Mining Egg. National Institute of Technology, Rourkela-769008 5-6<sup>th</sup> Feb.2005.*
- [70] Kumar Nikhil, M.Sundararajan and Asha Gupta (2005) Bio-treatment of Mine Water for Irrigation: A Conceptual Approach, 5<sup>th</sup> *International R&D Conference on Development and Management of Water and Energy Resources at Water Resources and Energy Departments, Govt. of Karnataka and CBIP, New Delhi at Bangalore 15-18<sup>th</sup> Feb, 2005.*
- [71] M.Sundararajan, Kumar Nikhil and M.S.Alam (2005) Prediction of Environmental Scenario of Coal Processing Plants through Modeling and Simulation with special emphasis on water and air pollution, *National Seminar on Environmental Planning & Management in Mining and Mineral Industries at Deptt. Of Geology, M.L.Sukhadia University, Udaipur-313001 on 11-12<sup>th</sup> March, 2005.*
- [72] M.Sundararajan, M.S.Alam and Kumar Nikhil (2005) Mathematical Modeling on Groundwater Contaminant Transport for Prediction of Toxic Elements in and around Mining Area in *Advance Training on Mathematical Modeling for Groundwater Studies in and around Mining Area Sponsored by Ministry of Science & Technology, Organized by HRD, CMRI During 10th to 23rd March 2005.*
- [73] M.S.Alam, M.Sundararajan and Kumar Nikhil (2005) Mathematical Modeling for Classification and Delineation of Groundwater Quality in and around Coal Mining area in *Advance Training on Mathematical Modeling for Groundwater Studies in and around Mining Area Sponsored by Ministry of Science & Technology, Organized by HRD, CMRI During 10th to 23rd March 2005.*
- [74] M.Sundararajan, M.S.Alam, and Kumar Nikhil (2005) Mathematical Imitation on Unconfined Wells for Estimating GPF as One of the Most Important Parameters for Groundwater Potential Studies in and around Mining Area Sponsored by Ministry of Science & Technology, Organized by HRD, CMRI During 10th to 23rd March 2005.
- [75] Kumar Nikhil, M.Sundararajan and M.S.Alam (2005) Application of Mathematical Modeling in Irrigation Projects for Quantification of Water and Solid Constituents in and around Mining Area Sponsored by Ministry of Science & Technology, Organized by HRD, CMRI During 10th to 23rd March 2005.
- [76] Kumar Nikhil and Asha Gupta (2005), "Nutrient Dynamics and Release on the Re-vegetated Coal Overburden Dumps", *International Seminar on Coal Science & Technology-Emerging Global Dimensions (GLOBALCOAL-2005) by CFRI, Dhanbad-826108 Jharkhand at New Delhi, 7<sup>th</sup> - 8<sup>th</sup> April, 2005.*

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 9, September 2017

- [77] Kumar Nikhil, M.Sundararajan, M.S.Alam, Mobin Ahmad, M.K.Chakraborty, Asha Gupta, B.K.Tewary and C.Bandhopadhyay (2005), "Green Development for the Coal Capital", *World Environment Day along with Seminar on Green Cities: Plan for the Planet by Institute of Engineers (INDIA) Dhanbad Local Centre at CMRI, Dhanbad, 5<sup>th</sup> June, 2005*.
- [78] M.S.Alam, Kumar Nikhil, M.Ahmad, M.Sundararajan, S.K.Gupta and A.Sinha (2005), "Strategic Plan for Employment Generation in Rural India", *National Conference on Rural Enterprise Leveraging Potential of Rural Jharkhand by Confederation of Indian Industry, Department of Industries, Govt. of Jharkhand, 15<sup>th</sup> June, 2005*
- [79] Kumar Nikhil, M.Sundararajan, M.S.Alam and Asha Gupta (2005), "Ancient Water Harvesting Structures: Status and Its Importance", *12<sup>th</sup> World Water Congress, New Delhi, India by International Water Resource Association and Central Board of Irrigation & Power, India at New Delhi, 22<sup>nd</sup> – 25<sup>th</sup> November, 2005*.
- [80] M Ahmad, Kumar Nikhil (2006), "Socio-cultural and geo-ecological dimensions of mining areas", Environment, Agriculture And Poverty In Developing Countries-Part-I (Ed) Dr. Ali Mohammad, Concept Publishing Company, New Delhi, Chapter.10, pp.149-159.
- [81] Kumar Nikhil (2006) "Zero Waste Management in Coal Mining Area: Vision for a New Millennium", *International Journal of Pollution Research, Vol.25 (1):2006:69-72*.
- [82] Kumar Nikhil (2006) "Medicinal Plants: Future Source of Pesticides", *Asian Journal of Microbiology, Biotechnology and Environmental Science, Vol.8 (1):2006:1-5*.
- [83] Kumar Nikhil (2006), "Phytoremediation of coal mining affected contaminated land-optimization with agronomical practices: A conceptual approach", *International Journal of Ecology, Environment and Conservation, Vol.13 (1)2006: 1-7*.
- [84] Kumar Nikhil (2006), "Menaces in the planted tree species on coal overburden dump", *International Journal of Ecology, Environment and Conservation, Vol.13 (1)2006: 8-16*.
- [85] Kumar Nikhil (2006) "Termiticulture: Environmental Technology for New Millinium", *Asian Journal of Microbiology, Biotechnology and Environmental Science, Vol.8 (1):2006:25-30*.
- [86] Kumar Nikhil (2006) "Heavy Metals in Medicinal Plants of Jharia Coalfield Area", *International Journal of Pollution Research, Vol.25 (1):2006:1-7*.
- [87] Kumar Nikhil (2006) "Suitable Fillers for the restoration of coal mined out area to achieve better & Economical Re-vegetation", in *Farmer Training on Reclamation on Coal Mined Out Areas in Meghalaya, North Easter Regional Institute of Water & Land Management (NERIWALM) Dolabari, P.O. Kaliabhomora, Tezpur-784027, India on 15<sup>th</sup> to 17<sup>th</sup> February, 2006*.
- [88] Kumar Nikhil (2006) "Prospects, Cultivation & Economics of Jatropa: A Bio-energy Plant for Degraded Land", in *Farmer Training on Reclamation on Coal Mined Out Areas in Meghalaya, North Easter Regional Institute of Water & Land Management (NERIWALM) Dolabari, P.O. Kaliabhomora, Tezpur-784027, India on 15<sup>th</sup> to 17<sup>th</sup> February, 2006*.
- [89] Kumar Nikhil, Asha Gupta, Brajendra Kumar Tewary and Amalendu Sinha (2006) "Jharkhand Rajya Key Jalsansadhono key Samuchit Upyog", *Sangosthi Jal Sanrakchan, DVC Training Center, DVC, Chandrapura, Bokaro, Jharkhand-825303 on 3<sup>rd</sup> to 4<sup>th</sup> March, 2006*.
- [90] Kumar Nikhil, M.Sundararajan, P.K.Arya, Asha Gupta and B.K.Tewary (2006) "Environmental Problems in and around coal washery complexes and an approach towards evaluation of waste disposal site", *International Seminar on Mineral Processing Technology (MPT-2006), Hotel Taz Coromandel, Chennai on 8<sup>th</sup> to 10<sup>th</sup> March, 2006 jointly organized by IIME & NML & TATASTEEL*
- [91] Kumar Nikhil, M.Sundararajan, Asha Gupta, B.K.Tewary and Amalendu Sinha (2006) "KhananChetromeyJalSanrakchan", in *Hindi Seminar on JalSanrakchanAivamParyavaran: Vaigyanikthathataknidristikone organized by VigyanBharati, Kanpur on 9<sup>th</sup> to 10<sup>th</sup> September, 2006*.
- [92] Kumar Nikhil, M.Sundararajan, Asha Gupta, B.K.Tewary and Amalendu Sinha (2006) "JalSanrakchanaiyvamprabandhan", *JalSanrakchan, SanchyanaiyvamPrabandhan at RRL Bhubneswar, Orrissa on 7<sup>th</sup> -8<sup>th</sup> December, 2006*.
- [93] Kumar Nikhil, Asha Gupta and B.K.Tewary (2006) "Optimal Greenbelt development around mining areas", in 8<sup>th</sup> Asian Academic Network for Environmental Safety and Waste Management (AANESVVM-2006) organized by Department of Chemistry and Centre with Potential for Excellence in Environmental Science, Anna University, Chennai-600025 (Madras) India on 10<sup>th</sup> to 13<sup>th</sup> December, 2006.
- [94] Kumar Nikhil, Asha Gupta and B.K.Tewary (2006) "Recovering drgraded ecosystem of mining affected areas", in National Conference on Environmental Pollution & Technology, Department of Zoology, Thakur Collage of Science & Commerce, Shyammarayan Thakur Road, Thakur village, Kandivili (E) Mumbai-400101 on 22<sup>nd</sup> to 23<sup>rd</sup> December, 2006.
- [95] Kumar Nikhil (2007) "Soil Quality Standards (SQS) for Bio-reclamation of Coal Overburden Dumps: ISO-14000 Requirements", *International Journal of Industrial Pollution Control, Vol.23 (1):2007:19-23*.
- [96] Kumar Nikhil (2007) "Net Primary Production and Relative Growth Rate of Planted Tree Species on Coal Overburden Dump", *International Journal of Pollution Research, Vol.26 (2):2007:189-192*.
- [97] Kumar Nikhil (2007) "Metallophytes: An Integrated Approach for Cleaning the Coal Mining Contaminated Lands", *Asian Journal of Microbiology, Biotechnology and Environmental Science, Vol.9 (3):2007:567-572*.
- [98] Manoj Kumar, Kumar Nikhil and M.Sundararajan (2007) "Micro-irrigation system for the improvement of livelihoods in rural India" *Seminar on TEHVITA-2007 Role of Engineering in providing better transportation facilities in micro-irrigational/ rainwater harvesting (cheaper tube wells) in the context of rural development of Jharkhand at BIT Sindri, Dhanbad, Jharkhand, on 2<sup>nd</sup> February, 2007*.
- [99] Kumar Nikhil, A.K.Singh, A.K.Soni, V.V.R. Prasad and B.K.Tewary (2007) "Recovering fragile ecosystem at Jowai coal mining areas ubderJainthia Hills of Meghalaya", *National Seminar on varied Perspectives of Biodiversity ICLES, MotilalJhunjunwala Collage, Sector-9A, Vashi, Nevi Mumbai-4000703 on 2-3<sup>rd</sup> February, 2007*.
- [100] Kumar Nikhil (2007) "KhananChetromeyJalPrabandhan", *World Water Day Program in Jharkhand organized by Water & Sanitation Watch (SAATHEE) at Ranch on 19<sup>th</sup> April, 2007*.
- [101] Kumar Nikhil (2007) "Damodar River: Effective Role in Industrial & Socio-economic Development in ChotanagpurPlatue" in *JalJagrukaAbhiayan 2007 at DAV School Patherdih to Surya MandirGhat, Sudamdih on 26<sup>th</sup> May, 2007*.
- [102] Kumar Nikhil and B.K.Tewary (2007) "Sustainable Management of Micro-irrigation System in Indian Agriculture", *National Seminar on People Participation in Conservation of Water Resources and Preservation of its Quality, IEI, Premises, Veena Building, Golf Ground, Dhanbad, Jharkhand on 30<sup>th</sup> May, 2007*.

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 9, September 2017

- [103] Kumar Nikhil, Asha Gupta, B.K.Tewary and Amalendu Sinha (2007) "Effect of Coal Mining on Soil Characteristics of Acidic Soils: A case study of Wapung Coal Mining Area of Jowai in Jaintia Hills district of Meghalaya State.", *BhartiyaVigyanSamelan, organized by Council of Science & Technology, Nehru Nagar, Bhopal-462007 on 23<sup>rd</sup> to 25<sup>th</sup> November, 2007.*
- [104] Kumar Nikhil, Asha Gupta, B.K.Tewary and Amalendu Sinha (2007) "Bio-treatment of Mine Water for Socioeconomic Development", *National Seminar on Eco-friendly Approach in Water Management and Treatment of Waste Water, H.D.Jain Collage Arrah, Bhojpur, Bihar on 12<sup>th</sup> to 13<sup>th</sup> December, 2007.*
- [105] Kumar Nikhil, Asha Gupta, B.K.Tewary and Amalendu Sinha (2007) "JayvBhibhidta, KhananParyavaranaivamArthikPaktch", *RastriyaSanghosthi "RasthiyaSanghosthiVartamanSandharveMey Jai VividitakaMahatouv, NBRI, Lucknow (U.P) on 22<sup>nd</sup> to 23<sup>rd</sup> December, 2007.*
- [106] Kumar Nikhil and MobinAhmad (2007) "Management of Irrigation Efficiency in Damodar River Basin", *Ed. Fifty Years of Indian Agriculture, Vol.II, Ali Mohammad, Abdul Munir and ShamsulHaque Siddiqui, Concept Publication, New Delhi, :December, 2007:pp78-90.*
- [107] Kumar Nikhil (2006),"Restoration of mining wastelands: status and strategies", *International Journal of Ecology, Environment and Conservation, Vol.14 (1)2008: 51-54.*
- [108] Kumar Nikhil, Asha Gupta, B.K.Tewary (2008) "Status, Constraints & Prospects of Small Scale Industries in Jharkhand", *National Seminar on Status, Constraints & Prospects of Small Scale Industries in Jharkhand at Golden Jubilee Hall, ISM Dhanbad on 28<sup>th</sup> to 29<sup>th</sup> January, 2008.*
- [109] Kumar Nikhil, A.K.Singh, A.K.Soni and V.V.R. Prasad (2008) "Effect of Coal Mining on Acidic Soils: A case Study in Jaintia Hills of Meghalaya", *Ed. Singh, A.K and S.C.Patra in Characterisation of Land Resources and Agro-Eco-Zones in India published by Wiley Publishers, Kolkotta (WB) December, 2008.*
- [110] Kumar Nikhil (2011) "Copper Mining in India", *Ed.KumarRakesh, Biniwala Rajesh and Sunil Kumar in "Critical Review of Research on Copper in Environment & Health", NEERI, Nagpur, pp.67-108.*
- [111] Kumar Nikhil and Sunil Kumar (2012) "Development of algae based technology to mitigate energy crisis in coal mining areas", *Ist Brainstorming Workshop on Waste to Energy, 24-25 August, 2012, Mumbai, Maharashtra, conducted by CSIR-NEERI, Nagpur.*
- [112] Kumar Nikhil, Amar Nath, B.K Tewary and Amalendu Sinha (2013)"Food management in India: Perspective, Prospects & Problems", *National Seminar on World Environmental day, organized by IIE, Dhanbad, 5<sup>th</sup> June, 2013.*
- [113] Kumar Nikhil (2013) "Algal Technology for providing Green Energy solution in Jharia Coalfield areas of District Dhanbad, Jharkhand", *National Seminar on Present Technology & safety Scenario in Mining & Allied Industries (PTSM-2013) from 25-27, February, 2013 at Department of Mining Engineering, IIT, BHU, Varanasi.*
- [114] Kumar Nikhil (2013) "Algae based technology to mitigate energy crisis in Dhanbad coal mining areas, District Dhanbad, Jharkhand", *International Conference on Energy Resource & Technology for sustainable development (ICERTSD-2013) from 7-8, February, 2013 at BESU, Sibpur, Howrah, W.B.*
- [115] Kumar Nikhil, K.B.Singh and Amalendu Sinha (2013)"Importance of Social Cost Benefit Analysis of Coal Mining Project in India", *National Seminar on POSTALE-2013, organized by NISM, CSIR-CIMFR, Dhanbad, 31<sup>st</sup> December, 2013 to 01<sup>st</sup> January, 2014.*
- [116] Iqbal Ansari and Kumar Nikhil (2014), "Lignocellulosic Bio Decomposition : A Green Solution in Coal Mining Areas", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.3 pp.104-106, March, 2014, (Online).*
- [117] GhanshyamPaswan, Saurabh Prakash and Kumar Nikhil (2014), "BIOFUEL AS GREEN ENERGY SOURCE: A REVIEW", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.3 pp. 124-126, March, 2014, (Online).*
- [118] Saurabh Prakash, GhanshyamPaswan, and Kumar Nikhil (2014), "LIQUID COAL AS A GREEN ENERGY: A REVIEW", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.3 pp. 141-143, March, 2014 (Online).*
- [119] Iqbal Ansari and Kumar Nikhil (2014), "Algal approach for Sustainable Development: A Critical Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.4 pp.83-85, April, 2014, (Online).*
- [120] GhanshyamPaswan and Kumar Nikhil (2014), "Biopurification of Waste Water ThroughAlgae – A Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.4 pp.71-73, April, 2014, (Online).*
- [121] Saurabh Prakash and Kumar Nikhil (2014), "Algae as a Soil Conditioner", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.4 pp.68-70, April, 2014 (Online).*
- [122] Kumar Nikhil (2014) "Development of algae based technology to mitigate energy crisis in coal mining areas", *International Journal of Environmental Technology & Management, Vol.17, No.2/3/4 May, 2014, pp.334-363. (Online)*
- [123] Deepanjali Singh and Kumar Nikhil (2014), "Algae for Lipid as Renewable Energy Source in Coal Mining Area: A Critical Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.5 pp.172-174, May, 2014 (Online).*
- [124] Kumar Gaurav, Kumar Nikhil and Iqbal Ansari (2014), "Bioreclamation of Mine Waste Water through Algae: An Experimental Approach", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.5 pp.265-269, May, 2014 (Online).*
- [125] Pramod Kumar and Kumar Nikhil (2014), "Environmental Impact Assessment (EIA) Study of Non-Metal Mines: A Critical Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.5 pp.324-326, May, 2014 (Online).*
- [126] Ashutosh Kumar and Kumar Nikhil (2014), "Environmental Impact Assessment (EIA) Study of Metal Mines: A Critical Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.6 pp.1-3, June, 2014 (Online).*
- [127] MdToufiqueKalim and Kumar Nikhil (2014), "Environmental Impact Assessment (EIA) Study of Coal Mines: A Critical Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.6 pp.112-114, June, 2014 (Online).*
- [128] Ashutosh Kumar Agrawal and Kumar Nikhil (2014), "Algal Biodiversity in Coalfield Areas – A Critical Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.6 pp.176-178, June, 2014 (Online).*
- [129] Pawan Kumar Gupta and Kumar Nikhil (2014), "Biopurification of Mine Wastewater through Aquatic Plants– A Review", *International Journal of Engineering & Technical Research (IJETR), Vol.2, No.6 pp.186-188, June, 2014 (Online).*
- [130] Deepanjali Singh and Kumar Nikhil (2014), "Extraction of lipid from algae grown in different coal opencast mining areas of Jharia Coalfield under District Dhanbad, Jharkhand:An Experimental Study", *International Journal of Current Research & Review(IJCRR), Vol.6, No.18 pp.12-16, September, 2014 (Online).*



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 9, September 2017

- [131] Anupam Kumar, Kumar Nikhil (2015), "Importance & Principle behind the Construction of Check Dam in Microwater-Shed Areas—A Critical Review", *IJEAS*, Vol.2, Issue.01, pp.17-18.
- [132] Anupam Kumar, Kumar Nikhil (2015), "Construction of Check Dam in Microwater-Shed Areas in Tundi Block of District Dhanbad, Jharkhand", *IJETR*, Vol.3, Issue.01, pp.75-77.
- [133] Ashutosh Kumar Agrawal and Kumar Nikhil (2015), "Algal Distribution Pattern and Quality of Water in Different Aquatic Environment of District Dhanbad", *International Journal of Science & Research (IJSR)*, Vol.4, No.2 pp.358-363, February, 2015 (Online).
- [134] MohnishPichhode and Kumar Nikhil (2015), "Effect of Copper Dust on Photosynthesis Pigments Concentration in Plants Species", *International Journal of Engineering Research and Management (IJERM)*, Vol.2, No.2 pp.63-66, February, 2015 (Online).
- [135] Pawan Kumar Gupta, Kumar Nikhil and Kumar Mayank (2015), "Phyto-remediation of Waste Water through Aquatic Plants for the Change Detection Analysis in the Chemical Parameters within the District Dhanbad, Jharkhand", *International Journal of Research in Engineering & Technology (IJRET)*, Vol.4, No.2 pp.243-252, February, 2015 (Online).
- [136] MohnishPichhode and Kumar Nikhil (2015), "Effect of Copper Mining Dust on the Soil and vegetation in India : A Critical Review", *International Journal of Modern Sciences and Engineering Technology (IJMSET)*, Vol.2, No.2 pp.1-5, February, 2015 (Online).
- [137] Jyotish Katre, Mohnish Pichhode and Kumar Nikhil (2015), "Effect of Different Mining Dust on the vegetation of District Balaghat, M.P – A Critical Review", *International Journal of Sciences and Research (IJSR)*, Vol.4, No.7 pp.1-5, July, 2015 (Online).
- [138] Jyotish Katre, Mohnish Pichhode and Kumar Nikhil (2015), "Growth of Terminalia bellirica [(gaertn.) roxb.] on the malanjkhanda copper mine overburden dump spoil material", *International Journal of Research—GRANTHAALAYAH*, Vol.3, No.8 pp.14-24, August, 2015 (Online).
- [139] Vyomendra Chaturvedi and Kumar Nikhil (2016), "Effect of Algae Fertilizer on the Growth of Vigna Radiata", *International Journal of Engineering & Technical Research (IJETR)*, Vol.4, No.1 pp.111-115, January, 2016 (Online).
- [140] Vyomendra Chaturvedi and Kumar Nikhil (2016), "Effect of Algal Bio-fertilizer on the Vignaradiata : A Critical Review", *International Journal of Engineering Research and Applications (IJERA)*, Vol.6, Issue 2 (part-1) February 2016, pp.85-94.
- [141] Dharendra Kumar and Kumar Nikhil (2016), "Vetiver Grass for Manifold Uses: A Critical Review", *International Journal of Engineering & Technical Research (IJETR)*, Vol.4, No.2 pp.146-152, February, 2016 (Online).
- [142] Shiv Kumar Gupta and Kumar Nikhil (2016), "Ground Water Contamination in Coal Mining Areas : A Critical Review", *International Journal of Engineering and Applied Research (IJEAS)*, Vol.3, Issue 2 February 2016, pp.177-182 (Online).
- [143] Shiv Kumar Gupta and Kumar Nikhil (2016), "Ground Water Status, Pollution and Maintenance in District Dhanbad, Jharkhand", *International Journal of Engineering and Technical Research (IJETR)*, Vol.4, Issue 3 March, 2016, pp.187-189.
- [144] Shiv Kumar Gupta and Kumar Nikhil and UtkarshDubey (2016), "Ground Water Quality Study in District Dhanbad, Jharkhand, India through GIS application", *International Journal of Advance Research in Science and Engineering (IJARSE)*, Vol.5, Issue 03 March, 2016, pp.535-539 (Online).
- [145] Shiv Kumar Gupta and Kumar Nikhil, Aditya Shrestkar and Gaurav Gehlot (2016), "Change Detection Analysis of Ground Water Quality and its management in District Dhanbad, Jharkhand, India", *International Journal of Advance Technology in Engineering and Science (IJATES)*, Vol.4, Issue 03 March, 2016, pp.636-641 (Online).
- [146] Ambika Asati, Mohnish Pichhode and Kumar Nikhil (2016), "Effect of Heavy Metals on Plants: An Overview.", *International Journal of Application or Innovation in Engineering & Management (IJAIEM)*, Vol.5, issue-03, pp.56-66, March, 2016
- [147] Dharendra Kumar and Kumar Nikhil (2016), "Effect of FYM, NPK and Algal fertilizers on the Growth & Biomass of Vetiver Grass [Vetiveria zizanioides L. Nass", *International Journal of Engineering and Applied Research (IJEAS)*, Vol.3, 85-89, Issue 3 March, 2016, pp. International Journal of Engineering and Applied Research (IJEAS), Vol.3, Issue 2 February 2016, pp.177-182 (Online).
- [148] Sandeep Meshram, Mohnish Pichhode and Kumar Nikhil (2016), "Carbon Sequestration by Teak (Teaktonagrandis ) Plantation at Malanjkhanda Copper Project, District Balaghat, M.P.", *International Journal of Current Research (IJCR)*, Vol.8, issue-03, pp.25907-25914, April, 2016.
- [149] Suman Dhar and Kumar Nikhil, 2017, Boyd's Diversity Index of Ponds in Coal Mining City Dhanbad, Jharkhand, India, *International Journal of Engineering and Technical Research (IJETR)*, Volume-7, Issue-8, August, 2017, pp.25-32.
- [150] Suman Dhar and Kumar Nikhil, 2017, Measurement for Diversity Indices of Algal Community in different Ponds in Coal Mining City Dhanbad, Jharkhand, India, *International Journal of Engineering and Applied Sciences (IJEAS)*, Vol.4, Issue.8, pp.47-54, August, 2017.
- [151] Suman Dhar and Kumar Nikhil, 2017, Study of Correlation Coefficient of different surface water with algal diversity in district Dhanbad, Jharkhand, India, M.Tech. Summer training Report 2017 submitted to CSIR-CIMFR and IIT-ISM, Dhanbad, Jharkhand
- [152] MohnishPichhode and Kumar Nikhil, 2017, Carbon Sequestration by Different Tree Species at Malanjkhanda, district Balaghat, Madhya Pradesh, India, *American Journal of Engineering Research (AJER)* [Communicated].
- [153] Kumar Nikhil, 2017, "Development of Green Roof Technology (GRT) for the abatement of pollution and radiation in the city influenced by industrial pollution", A project proposal submitted to MoEF&CC, New Delhi for funding.
- [154] Mohnish Pichhode and Kumar Nikhil, 2017, "Development of Green Roof Technology (GRT) for the abatement of pollution and radiation in the city influenced by industrial pollution", presented at Raipur Conference - International Conference on Innovative Trends & Technologies in Engineering Sciences & Education at Columbia Institute of Engineering and Technology Raipur, Chhattisgarh(India) [Approved by AICTE, Ministry of HRD, New Delhi, Affiliated to CSVTU, Bhilai (C.G.)] on 08 September 2017 pp.558-594.
- [155] Suman Dhar and Kumar Nikhil, 2017, Algal Biodiversity and Quality of Ponds Water within the Coal City Dhanbad, *International Journal of Engineering and Applied Sciences (IJGAES)* [Communicated].
- [156] Mohnish Pichhode and Kumar Nikhil, 2017, "Development of Green Roof Technology (GRT) for the abatement of pollution and radiation in the city influenced by industrial pollution", *International Journal of Advances Research in Science and Engineering (IJARSE)*. Vol.No.6 issue no.09, September, 2017, pp.84-120.
- [157] GEER, Gujarat Ecological Education and Research, Gandhinagar-382 007, Gujarat, India, <http://timesofindia.indiatimes.com/city/ahmedabad/Teak-absorbs-max-CO2-from-air-helps-check-global-warming/articleshow/51721842.cms?>
- [158] Himanshu kaushik, 2016, "Teak absorbs max CO2 from air, helps check global warming", *The Times of India*, Apr 7, 2016,

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 9, September 2017

- [159] "GRIN Taxonomy for Plants - Tectona". United States Department of Agriculture. October 5, 2007. Retrieved September 22, 2013.
- [160] *Tectona grandis*. *Flora of China* 17: 16. Accessed online: 17 December 2010.
- [161] Tangmitcharoen, S. and J. N. Owens. 1996. Floral biology, pollination, pistil receptivity, and pollen tube growth of teak (*Tectona grandis* Linn f.). *Annals of Botany*, 79(3): 227-241. doi:10.1006/anbo.1996.0317.
- [162] Bryndum, K. and T. Hedegart. 1969. Pollination of teak (*Tectona grandis* Linn.f.). *Silv. Genet.* 18: 77-80.
- [163] Tewari, D. N. 1992. A monograph on teak (*Tectona grandis* Linn.f.). International Book Distributors.
- [164] Kaosa-ard, A. 1981. Teak its natural distribution and related factors. *Nat. His. Bull. Siam. Soc.*, 29: 55-74.
- [165] International Organization for Plant Information (IOPI). "Plant Name Search Results"(HTML). *International Plant Names Index*. Retrieved 17 December 2010.
- [166] Moldenke, H. N. 1975. Notes on new and noteworthy plants. LXXVII. *Phytologia*, 31: 28.
- [167] [eol.org/pages/579742/overview](http://eol.org/pages/579742/overview)
- [168] [www.ecoindia.com](http://www.ecoindia.com) > Flora > Trees
- [169] [www.Teak%20Wood%20Farming%20Information%20Detailed%20Guide%20\\_%20Agrifarming.in.html](http://www.Teak%20Wood%20Farming%20Information%20Detailed%20Guide%20_%20Agrifarming.in.html)
- [170] [www.Sagwan%20Crop%20Information%20Guide%20\\_%20Apni%20Kheti.html](http://www.Sagwan%20Crop%20Information%20Guide%20_%20Apni%20Kheti.html)
- [171] Kasischke, E.S (2000), " Boreal ecosystem in the global carbon cycle, In: Fire, climate change and carbon cycling in the boreal forest (Eds. E.S. Kasischke & B.J.Stocks). Ecological studies series. New York, USA, Springer-Verlag.
- [172] Liu, Y.C., Yu, G.R., Wang, Q.F. & Zhang, Y.J (2012) Huge carbon sequestration potential in global forests, *Journal of resources ecology*; 3:193-201.
- [173] Eggleston, S., Buendia, L., Miwa, K., Ngara, T. & Tanabe, K. (2006), "Inter-governmental Panel on climate change. In: IPCC on climate change Guidelines for National Greenhouse Gas Inventories (Edt. Kanagawa). Vol.4.Published by Institute for Global Environmental Strategies.
- [174] IPCC (2001) Climate change 2001, working group-I: The scientific basis. Cambridge University Press, New York. Pp. 881.
- [175] IPCC (2007) Fourth Assessment Report, Summary for Policy Makers-The Science of climate change. Cambridge University Press, New York. Pp.18.
- [176] Behera, L.K., Nayak, M.R., Gunaga, R. P., Manmohan J. Dobriyal and Jadeja, D.B (2015), "Potentiality of planted forest towards carbon sequestration and climate change mitigation", *International Journal of Usuf. Mngt.* 16 (1): 82-91 (2015).