IMPACT OF EUCALYPTUS PLANTATIONS ON GROUND WATER AVAILABILITY IN SOUTH KARNATAKA

IMPACT DES PLANTATIONS D'EUCALYPTUS SUR LA DISPONIBILITE DES EAUX SOUTERRAINES AU SUD DU KARNATAKA

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ABSTRACT

Eucalyptus is a controversial trees globally, due to its merits and as well as notoriety. Its merits like fast growing habit, quick adaptations to wide ranging ecological situations, several industrial applications and as means of livelihood for unprivileged have elevated it to one of the most desirable tree species to be introduced in afforestation, farm forestry and social forestry programmes. Nevertheless, Eucalyptus is also known to cause a number of environmental hazards like depletion of groundwater, dominance over other species by allelopathic effects, loss of soil fertility and negative impacts on local food security issues.

A study initiated to document and quantify the adverse impacts of growing Eucalyptus in Kolar district of Karnataka state in India indicated that 20 years of continuous cultivation of Eucalyptus in private and public lands deepened the water level in freshly dug bore wells to 260 m, as compared to the mean depth of water level in bore wells (177 m) in the study area of 21 villages of Kolar district. The distance from the eucalyptus plantation had negative correlation with the depth of freshly dug bore wells. The bore well yields were reduced by 35 to 42 per cent in the study area during the span of 3-5 years, when they were located within a distance of 1 Km from Eucalyptus plantations.

The reduction was to the tune of 25 to 37 percent, when bore wells were located within a distance of 1-3 Km from such plantations. These observations were recorded under identical set of soil, rainfall, rock formations and cropping patterns. Reduced irrigated area, reduced profitability, increased cost of lifting the water and resorting to digging more bore wells (with a blind hope that farmers may strike more water in new bore wells) are recorded as prominent negative impacts of growing Eucalyptus continuously for the last 20 years

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RESUME

L'eucalyptus est un arbre controversé dans le monde, en raison de ses mérites ainsi que sa notoriété. Ses mérites, comme la croissance rapide, les adaptations rapides aux situations écologiques de grande envergure, plusieurs applications industrielles et un moyen de subsistance pour les non-privilégiés. Tous ces aspects l'ont élevé à l'un des arbres les plus souhaitables pour être introduits dans le boisement, l'agroforesterie et des programmes de foresterie sociale. Néanmoins, l'eucalyptus est également connu pour causer un certain nombre de risques environnementaux, comme l'épuisement des eaux souterraines, la domination sur les autres espèces par des effets allélopathiques, la perte de fertilité des sols et des impacts négatifs sur les questions locales de sécurité alimentaire.

Une étude censée à documenter et à quantifier les impacts négatifs de l'Eucalyptus en Kolar, district de l'état de Karnataka en Inde, a été lancée; la zone d'étude étant 21 villages du district de Kolar. Cette étude a indiqué que pendant les 20 dernières années, la culture continue d'Eucalyptus dans les terres privées et publiques a réduit le niveau d'eau à 260 m dans des puits fraîchement creusées, par rapport à la profondeur moyenne du niveau d'eau dans forages (177 m) dans la zone d'étude. La distance de la plantation d'eucalyptus a une corrélation négative avec la profondeur de puits forés fraîchement creusés. Quand ils se trouvaient dans un rayon de 1 km de plantations d'eucalyptus, les rendements de puits avaient été réduits de 35 à 42 pour cent dans la zone d'étude pendant la durée de 3 à 5 ans.

Quand forages se trouvaient dans un rayon de 1-3 km de ces plantations, la réduction a été entre 25 à 37 pour cent. Ces observations ont été enregistrées sous un ensemble identique de sol, des précipitations, des formations rocheuses et des formes de culture. Les suivants sont comptabilisées comme des impacts négatifs importants sur la culture continue d'eucalyptus depuis les 20 dernières années : la réduction des superficies irriguées, une rentabilité réduite, l'augmentation du coût du transport de l'eau et de recourir à creuser plus de puits artésiens (avec un espoir aveugle que les agriculteurs peuvent trouver plus d'eau dans de nouveaux forages).

Mots clés: *Eucalyptus, eaux souterraines, district de Kolar à Karnataka (Inde), réduction des rendements en puits.*

1. INTRODUCTION

No other plant species has stirred up so many controversies as Eucalyptus has, in different parts of the world. As a fast growing, remunerative and consistently demanded industrial wood, Eucalyptus has witnessed an unfettered support in most countries. Besides being viewed as suitable forest plantation for unused, denuded marginal dry lands of poor fertility and as suitable cheap alternative fire wood for poorer communities, it is promoted as a source of livelihood for under-privileged in many developing economies, including India. The recently evolved genetically modified Eucalyptus in US is a testimony of its popularity and public acceptance. Being highly adaptable to widely varying eco-systems, it has found its ways in afforestation programmes of government lands, marginal lands and even fertile lands

of individual farms often replacing food, fodder and fuel crops. It has been even regarded as best species for denuded areas, where no other tree species could be established quickly. It is a source of firewood for the poor and source of fiber for industries. The Eucalyptus is accepted worldwide as most desirable species, when marginal, poorly managed, rocky and public area is to be occupied by vegetation. Farmers have known it as least capital- intensive no-maintenance crop with assured returns.

But, negative impacts of growing Eucalyptus outweigh all these benefits. Eucalyptus is in the centre of a number of controversies like allelopathy, loss of soil fertility, adverse effects on local food security, replacement of conventional forests, besides being a prime cause for various hydro-ecological imbalances of an eco-system. Strong protests against Eucalyptus are registered in equal proportion to the strong support offered to it throughout the world. India, with large Eucalyptus plantations, is not an exception to this global 'Eucalyptus controversy'. An evidence of strong negative impact of unplanned government sponsored promotion of Eucalyptus plantation on dwindling ground water resources in southern Karnataka over the last 20 years is discussed in this paper.

Eucalyptus was introduced to Karnataka in 1946 (Gangadharappa et al 2003). Karnataka government promoted fast growing Eucalyptus plantation to cover the denuded areas, as a part of afforestation programme since 1960s, even finding a buying partner in corporate sector to purchase its wood for industrial purposes (coverage 70,000 ha). Later, as a sequel to modified Indian Forest Act during 1988, Eucalyptus was promoted as a profitable, no maintenance and low investment crop in cultivated lands, in the style of farm forestry (1,40,000 ha). Karajagi *et al* (2009) have documented an area of 2.1 lakh hectares of Eucalyptus in Karnataka. But, in recent years, Government of Karnataka has checked the spread of Eucalyptus. In the latest notification of Government of Karnataka in January 2011 (Anonymous, 2011), its cultivation is banned in western Ghats of the state due to reported loss of soil fertility. During the course of popularization of Eucalyptus in 1980s, the major spread of Eucalyptus was restricted to two districts namely, Bangalore (rural) and Kolar, replacing 70,000 ha ragi, a local staple food grain crop. Almost 90% of Eucalyptus area in Karnataka is in these two districts. The farmers of these two districts have continued to grow this easy crop, requiring low capital and attention. Other districts have negligible area. As these two districts have witnessed serious depletion of underground water as compared to other districts, this study was initiated in Kolar district to find the role of Eucalyptus plantation in faster exhaustion of groundwater resources.

2. WATER RELATIONS IN EUCALYPTUS PLANTATION

Eucalyptus is a unique tree species as compared to other perennial trees, as regards its adaptability to water relations. It can efficiently adjust to surplus water situations, when its water requirement rises to as high as 90 liters per plant per day. It can also successfully grow under water scarcity, when its water requirement comes down to 40-50 liters per plant per day. Unlike other perennial species, it is able to draw water from large area in the vicinity of its root system. In stress situation, its roots can grow even up to 6-9 m and extract more water. In fact, Eucalyptus along with *Dalbergia* is recommended as bio-drainage species to poorly drained areas suggesting its great potentiality of water uptake.

Engel (2005) during their study of hydrological consequences of Eucalyptus in Argentine pampas found that it utilized ground water (67% of its total water use) as well as water from upper vadose zone, which is the source of supply to ground water. He also found that steeper hydraulic gradient induced by the Eucalyptus plantation in 40 ha land forced the surrounding water to enter the plantation area, suggesting that it has capacity to make use of water from surrounding areas by inducing water flow gradient towards the plantation area. This corroborates the earlier study made by Thorbum and Walker (1993) who also found evidence of Eucalyptus drawing water with a greater suction from surrounding areas. The proportion of groundwater used by eucalyptus trees from distant places from the plantation increased from 40 to 63% as the surface soil dried out. They indicated that water was still being extracted from the surface soil even at soil water potentials <-2.0 MPa. Dabral et al (1987) found that the fibrous roots of Eucalyptus can expand to 18 m within the soil depth of 30-60 cm corroborating the evidences found by Engel (2005) as well as Thorbum and Walker (1993). Khan and Mohammad-Ul-Hasan (2007) found direct evidence of depleting ground water resources due to Eucalyptus plantation in Udigram Swat valley of Pakistan, leading to drying of wells or digging them to deeper layers. They also found evidence to infer that it caused change in the flow of underground water from spring to summer months causing drier springs.

Authors like Prabhakar (1998) have argued that Eucalyptus is more efficient in its water use considering the water used per unit of dry matter produced, as compared to native tree species. But, rapid growth of Eucalyptus (8-10 times than native tree species) exhausts more water rapidly disturbing the water balance in deeper strata, even though it can produce more dry matter per unit of water used. Sargent (1998) inferred that fast growing plantations of Eucalyptus can increase the drought potential of the area, especially at the downstream.

Although depletion of groundwater resources can be caused by a number of other hydrological reasons or over-drawal for irrigation purposes, the above evidences suggest that Eucalyptus plantations can aggravate the depletion much earlier than expected by other reasons

3. METHODOLOGY OF THE STUDY

The primary data for the study was collected during 2006-07 from 21 selected villages of Chikkaballapur and Siddlaghatta taluks of Kolar district (which are now classified in Chikkaballapur district after reorganization). Apart from socio-economic data, the ground level data like the water yield from bore wells, average depth of bore well, as well as nearness to the Eucalyptus plantation and its area were collected from as many as 85 farmers owning bore wells. The data from 25 freshly dug bore wells and 60 existing bore wells (of 3-5 years age) was collected. This was compared with respective data of 3-5 years back, as collected from perceptions of the farmers, including the change in the cropping pattern. The secondary data about the depletion of underground water resources was also collected to substantiate the reduced water yields in bore wells, drying of bore wells in the study area. The study area received an annual rainfall of 860 mm, out of which 670 mm was received between May to October. For the purpose of study, 25 newly dug bore wells were selected in the study area to know their depth as influenced by Eucalyptus plantation of more than 2 hectares within 1 Km distance and between 1-3 Km distances. Observations regarding the impact on reduced bore well yields were made on as many as 60 bore wells 3-5 years old.

4. RESULTS AND DISCUSSION

The results indicated that the depth of freshly dug bore wells was 26.3 to 47 per cent more in situations where the bore wells were located within 1 Km of Eucalyptus plantations of more than 2 hectares. Against the average depth of 177 m, the depths of freshly dug bore wells in the vicinity of Eucalyptus plantations were in the range of 224 – 261 m (Figure1). This effect was found more prominent in downstream areas of the watershed. However, the negative impact of Eucalyptus plantation was mitigated slightly, when the new bore wells located between 1 to 3 Km were considered. The depth of such bore wells was 25.2 to 31.9 per cent more as compared to average depth in the area. The rainfall pattern, percolation rates of soil and rock formations being similar in the entire area, Eucalyptus plantation must have drawn up more water from deeper layers and disturbed the natural recharge of the aquifers. Similar findings were recorded by Khan and Mhammod-Ul-Hasan (2007). Given the intensive agricultural characteristic of the study area, more farmers have resorted to digging newer bore wells to greater depths and the groundwater is seriously over exploited. Central Ground Water Board has classified these two districts as over exploited districts (>100 per cent) as compared to all other districts of Karnataka, which are considered either as grey area (< 85 >65 per cent) or under exploited area (< 65 per cent) (CGWB, 2007).

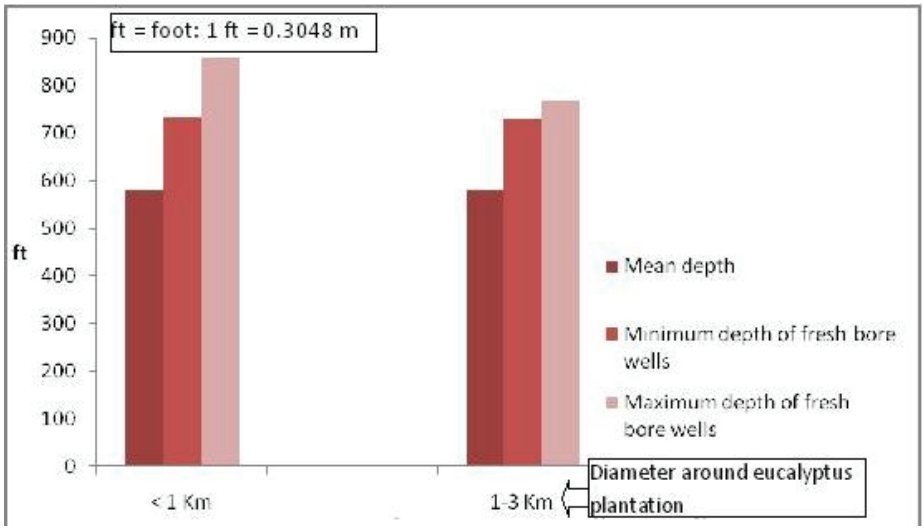

Fig. 1. Depth of newly dug bore wells as influenced by distance from Eucalyptus plantation

Obviously, it cannot be argued that Eucalyptus plant roots would reach the depths of 150 – 180 m to draw water. But, their capacity to create larger suction in the upper vadose zone would seriously reduce the natural movement of water to ultimately reduce the supply to the deeper aquifers, as earlier found by Engel (2005).

The study also recorded the water yield levels from 44 bore wells of 3-5 years age. It indicated that the bore wells dug within a distance of 1 Km from Eucalyptus plantation of more than 2 hectares recorded 35-42 per cent reduced water yields as compared to their original discharge. For the remaining 16 bore wells located between 1-3 Km distance from Eucalyptus

plantation of more than 2 hectares, the reduction in the water yields was to the tune of 25-37 per cent in the span of 3-5 years (Table 1). The observations regarding the reduced bore wells yields in the areas around Eucalyptus plantation of more than 2 hectares must have been due to excessive drawal of percolated water by well grown Eucalyptus plantations as found by Thorbum and Walker (1993). It may be noted that all other factors like soil type, its percolation rate, rock formations, rainfall variations over the years and even cropping patterns remained common for both the set of observations.

Table 1. Reduction in bore well yields (lps) by Eucalyptus plantation

Bore well depth (ft)	Initial water yields (mean of n borewells)	Water yields after 3-5 years (mean of n borewells)	Reduction in bore well yields
Bore wells within 1 Km diameter of Eucalyptus plantation of > 2 ha (n=44)			
137-167 m (n=12)	2.95	1.92	34.9 %
167-198 m (n=18)	2.74	1.67	41.6%
198-229 m (n=9)	2.65	1.60	39.6%
229-259 m (n=5)	2.44	1.42	41.8%
Mean	**2.695**	**1.653**	
Bore wells within 3-5 Km diameter of Eucalyptus plantation of > 2 ha (n=16)			
137-167 m (n=5)	3.15	2.36	25.0%
167-198 m (n=6)	2.99	2.15	28.0%
198-229 m (n=4)	2.68	1.77	33.9%
229-259 m (n=1)	2.51	1.58	37.0%
Mean	**2.833**	**1.965**	

Considering the negative impacts, it may not be wise to continue with Eucalyptus plantations in these districts in the larger interest of protecting the ground water resources. It may be even necessary to ban its cultivation by law. Further expansion of Eucalyptus plantation in other districts may be suitably curbed, even though it may be a more profitable and no-maintenance crop, in the larger interest of the groundwater resources.

5. CONCLUSIONS

No other plant species has stirred up so many controversies as Eucalyptus has, in different parts of world. As a fast growing, remunerative and consistently demanded industrial wood-Eucalyptus has witnessed an unfettered support in most countries, it was introduced to. Besides being viewed as suitable forest plantation for unused marginal dry lands of poor fertility and as suitable cheap alternative fire wood for poorer communities, it is promoted as a source of livelihood for under-privileged in many developing economies, including India. The recently evolved genetically modified Eucalyptus in US is a testimony of its popularity and public acceptance. Being highly adaptable to widely varying eco-systems, it has found its ways in afforestation programmes of government lands, marginal lands and even fertile

lands of individual farms often replacing food, fodder and fuel crops. But, negative impacts of growing Eucalyptus outweigh all these benefits. Eucalyptus is in the centre of number of controversies like allelopathy, loss of soil fertility, adverse effects on local food security, replacement of conventional forests, besides being a prime cause for various hydro-ecological imbalances of an eco-system. Strong protests against Eucalyptus are registered in equal proportion to the strong support offered to it throughout the world. India, with large Eucalyptus plantations, is not an exception to this global 'Eucalyptus controversy'. An evidence of strong negative impact of unplanned government sponsored promotion of Eucalyptus plantation on dwindling ground water resources in southern Karnataka over the last 20 years is discussed in this paper.

Karnataka government promoted fast growing Eucalyptus plantation to cover the denuded areas, as a part of afforestation programme since 1960s, even finding a buying partner in corporate sector to purchase its wood for industrial purposes (coverage 70,000 ha). Later, as a sequel to modified Indian forest Act during 1988, Eucalyptus was promoted as a profitable, no maintenance low investment crop in cultivated lands, in the style of farm forestry (1,40,000 ha). However, the major spread of Eucalyptus was restricted to two districts namely, Bangalore (rural) and Kolar, replacing 70,000 ha ragi, a staple food. Almost 90 percent of existing Eucalyptus area in Karnataka is in these two districts. The farmers have continued to grow this easy crop, requiring low capital and attention. But, in these twenty years of Eucalyptus plantation, the ground water level in these districts has dwindled alarmingly as compared to other districts. This is evidenced by the report of Central Ground Water Board classifying these districts as most critically over- exploited areas.

The study indicated that 20 years of continuous cultivation of Eucalyptus in private and public lands deepened the freshly dug bore wells up to 260 m, as compared to mean depth of bore wells (177 m) in the study area of 21 villages of Kolar district. The distance from the eucalyptus plantation had negative correlation with the depth of freshly dug bore wells. The bore well yields were reduced by 35 to 42 per cent in the study area during the span of 3-5 years, when they were located within a diameter of 1 Km from Eucalyptus plantation. The reduction was to the tune of 25 to 37 percent, when bore wells were located within a diameter of 1-3 Km from such plantations. These observations were recorded under identical set of soil, rainfall, rock formations and cropping.

Eucalyptus is a well known forest species of high water uptake ranging from 50 Lt/d/plant to even 90 Lt/d/plant, depending upon the adequacy of supply. But, it is also reported that, in stress situation, its roots can grow even up to 20-30 feet and extract more water. In fact, Eucalyptus along with Dalbergia is recommended as bio-drainage species to poorly drained areas suggesting its great potentiality of water uptake. It may not be wise to continue Eucalyptus plantations in these districts, in the larger interest of protecting the ground water resources. It may be even necessary to ban its cultivation by law.

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