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Potential of Bio-drainage for Soil Salinity and Water-Logging Management

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Abstract

Bio-drainage technology is used for reclamation of salt affected water-logged areas. It involves growing of vegetation specially trees with high transpiration rate to control salinization and water logging in the area. It is resulting in multiple benefits including improved yield, nutrient use efficiency, cropping intensity and making land more arable to grow different crops, which were otherwise unfeasible on the water-logged soil. *Eucalyptus*, *Acacia, Casuarina*, *Dalbergia, Populus, Syzigium*, *Leucaena*, *Prosopis*, etc. are some popular options for bio-drainage. The consumption of water during the growing season depends on age, depth of groundwater level, species, spacing, and other conditions. The water use capacity of trees and other crops decreases with increase in water salinity. For example, in Eucalypt species when water salinity increases to about 8 dS/m transpiring capabilities are reduced to about one-half of potential. Therefore, salt tolerant tress species are considered for bio drainage. Careful planning and implementation of biodrainage system can be an effective alternative to traditional engineering drainage measures.

Introduction

Biological drainage in short known as bio-drainage is a natural method for drainage in which we grow vegetable cover, wood species and agricultural crops which have high transpiration capacity and during their life span they can absorb large quantity of soil moisture which results in lowering of groundwater table. Plant consumptive water use generally varies between 6500 and 28000 m^3 ha^{-1} yr^{-1} and an ideal tree plantation has potential to lower groundwater table by nearly 1-2 m in a period of 3-5 years. Trees spices like as *Eucalyptus*, *Acacia, Casuarina*, *Dalbergia, Populus, Syzigium*, *Leucaena*, *Prosopis*, etc. are referred for bio-drainage as they effectively work to lower shallow groundwater tables and reduce salinity. Combination of tree species such as *Populus, Eucalyptus* along with field crops in a unified agro-forestry system is a good option. These tree species can also be planted on field bunds, approach roads or dykes of ponds. This has also numerous other benefits like reuse of wastewater and conservation of nutrient energy into biomass, carbon sequestration, environmental sanitation and eco-restoration etc. Vegetation affects soil-water storage components of the soil water balance by evapotranspiration and when natural vegetation is cleared or replaced by other crops or tree plantations, land is brought under irrigation by means of canal or ground water. Hence, the evapotranspiration and seepage losses are affected under the new land use system; they are either increased or reduced resulting high or low water table condition. This high water table condition causes water logging under such conditions plantations of fast growing tree species such as eucalyptus having high consumptive use rate successfully control groundwater accession.

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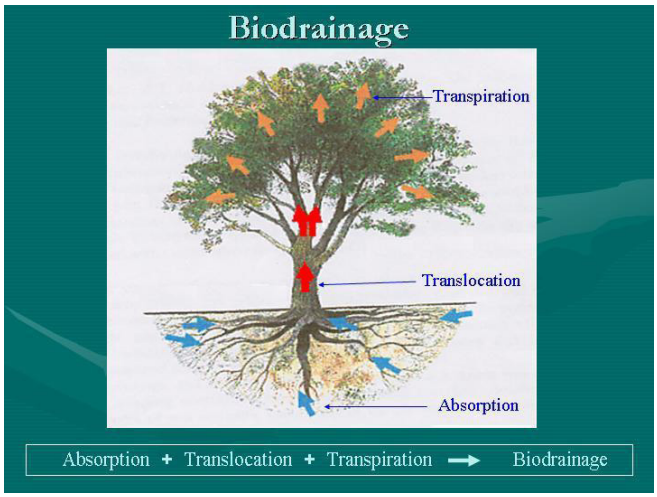

Figure 1: Concept of bio drainage (Jeet-Ram *et al*., 2008)

Trees have deep-rooting characteristics which make them exceptionally efficient users of water and because of deep-rooted they can access water that several meters below the surface. Salt balance is a major factor determining the sustainability of plant water use. There slat tolerant varieties of trees are used for bio drainage. When salts are moving into the root zone and bio drainage results in salt accumulation, engineering measures should be used to remove the excess salt and make the system sustainable.

Applications of Bio-drainage

- Recharge control
- Groundwater flow interception
- Discharge enhancement
- Water table control
- Channel seepage interception
- Bio drainage cum conventional drainage systems.

The merits and demerits of bio drainage technique over the conventional engineering-based drainage systems are as given below:

Advantages of Bio-drainage

- Farmers recognise the benefits of drainage but cannot afford cost of engineering drainage systems. This where bio-drainage come as it is relatively less costly and very affordable.
- No maintenance and operational costs after initial establishment.
- No problem drainage effluent and its disposal. Hence, ecologically safe.
- Doesn't depreciation instead increase in worth with age and alternative income by production of food, fodder, timber, fuel wood and other valuable products.
- Preventive as well as curative system for water-logging and salinity with no severe side effects.
- Sequesters carbon and earn carbon credits.
- Increases green cover and moderates the temperature of the surrounding by transpiration.
- Mitigates harmful greenhouse gases by absorbing CO_2 and releasing O_2.
- Also acts as wind break and prevents soil erosion.
- Increase in cropping intensity and soil organic carbon build-up.
- More choice among arable crops including pulses and oilseed which otherwise are sensitive to water-logging and salinity.
- Higher crop yields and nutrient use efficiency.
- Increased employment generation and poverty alleviation.

Table 1: Suitability of tree spp. for saline soils (FAO, 2002)

Tolerant (ECe25-35 dS/m)	*Tamarise troupii, T. artiaulata, Prosopis juliflora, Pithe cellobium dulce, Parkinsonia aculeata, Acacia farnesiana*
Moder-ately tolerant (ECe15-25 dS/m)	*Callistemon lanceolatus, Acacia nilotica, A. pennatula, A. tortilis, Casuarina glauca 13144, C. glauca 13987, C. obessa 27, C. glauca (FRI), C. equisetifolia (FRI), Eucalyptus camaldulensis, Leucaena leucocephala, Erescentia alata*
Moderately sensitive (ECe10-15 dS/m)	*Casuarina cunninghamiana (FRI), C. cunninghamiana (Aust.), Eucalyptus tereticornis, Acacia auriculiformis, Guazuma ulmifolia, Leucanea shannonii, Samanea saman, Albizzia caribea, Senna atomeria, Ferminalia arjuna, Pongamia pinnata*
Sensitive (ECe7-10 dS/m)	*Syzgium cumimi, S. fruticosum, Tamarindus indica, Salix app., Acacia deanei, Albizia quachepela, Alelia herbertsmithi, Ceaselpimia eriostachya, C. velutina, Halmatoxylon brasiletto*

Constraints

- Decreased land for cultivation as may be 10-15 % of the total holding can be cover by bio-drainage plantations.
- Requires irrigation and proper maintenance during early stage for the survival of the trees.
- Not an immediate solution as system may not be effective in the early growth stages as trees need time to grow and reach its full potential.
- Competition between trees and crops for light, moisture, nutrient, etc.
- Gradual decrease in capacities of trees as for consumptive rate of water decrease with age after maturity.

• There can be salt accumulation in soil profile which will affect tree growth and crop.

• No actual control over the system; ground water table cannot be maintained properly.

Important Consideration for Successful Bio-Drainage System

The aim of a biodrainage system is to remove excess groundwater in the by harnessing power of trees species/ vegetation that have high transpiration capacity. The following issues should be considered in the development of bio-drainage systems:

Water balance: Bio-drainage system should be able to remove excess groundwater without limiting water supply fir the crop.

Plantation area: Area under bio-drainage should be area should be kept as small as possible. Conversion of high-value cropping land to relatively low-return forestry can lead to hardships for farmers so area should be utilized so that there is no loss of productive resources.

Salt tolerance: Groundwater qualities vary greatly spatially and temporally and have usually a higher salinity than other irrigation supplies. Salinity can limit the consumptive potential trees species used for bio-drainage therefore during selection it should be kept in mind that trees species should be salt tolerant.

Drawdown of water table: Bio-drainage system act as bio pumps they transpire water from root zone consequently resulting in lowering of the water table in the surrounding area. This depends on the tree/ crop's water use, the rate of recharge, age, depth of groundwater level, hydraulic conductivity, spacing, and other conditions in the surrounding area. Therefore, all this factors should be kept in mind while planning and implement of the bio-drainage projects so that the "drainage" function is not lost.

Salt balance: Bio-drainage can lead to accumulation of salts in root zone and also from irrigation. For sustained production of crop and proper working of bio-drainage system salt balance should be appropriately maintained. When there are excess salts same should be harvested and removed from field.

Economic aspects: Costs associated with planting and maintenances are more than the income from its harvesting in later years. Some kind of incentives and help should be given to landholders to promote bio-drainage and increase people participation.

Social acceptance: Bio-drainage plantations are fundamentally different from traditional crops and work should be done to educate the rural society about it to increase its acceptance and development of new markets facilities should be encouraged. The security arrangements for these plantations differ from those for normal crops to avoid illegal cutting or pruning for fuel wood and also care should be taken to prevent forest fires that can destroy the results of many years of labour and other resources.

Conclusion

Water-logging and its associated soil salinity are the major obstacles to the sustainability of irrigated agriculture. Although conventional engineering drainage technologies such as subsurface or vertical drainage are being widely used to combat the problem, they are very costly and generate effluent which is very difficult to dispose off without causing harm to environment. Bio-drainage provides good alternative option to this trees species that are salt tolerant can successfully control water-logging and decrease ground water table level. There is need engage rural society and generate awareness regarding bio-drainage options to increase active participation of local communities towards bio-drainage systems so that we can reap maximum benefits of this technology.

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