THEME:
CLIMATE CHANGE AND ENVIRONMENTAL MANAGEMENT

Title of the technology

Utilization of wastewater in afforestation to increase aesthetic value and fuelwood supply in suburban areas of desert cities

A. Nature of technology

Wastewater utilization in afforestation

B. Process in brief

Shortage of fodder and fuel wood is the common phenomenon in arid and semiarid areas and requires immediate remedial measures to ease out this problem. One of the important measures is tree plantation. However, owing to the uneven distribution of rainfall and long dry spell, water stress and nutrient deficiency constitutes the major constraint in the establishment of planted tree sapling on arid land. Added to this, better quality of water is becoming an increasingly scarce resource in arid areas and even if available are utilized for irrigating agricultural/ fruit crops and over the priority to the lands where afforestation and greening is needed to abate the process of soil degradation and water pollution. Increasing population in urban areas and the consequent industrialization draw heavy quantity of precious water resources and finally provide a large quantity of by product, what is called wastewater or municipal effluent. Both the need to conserve water and to safely and economically dispose of wastewater, make the use of municipal effluent in tree plantation as a very feasible option. Furthermore, wastewater reuse reduces fertilization rate and provide a low cost source of irrigation water. Trees and shrubs are the better alternative to dispose of municipal effluent, because of their high growth rates and potential to produce high biomass on annual basis, ability to sustain very high loading rate, no direct link with food chain and profused root system to control leaching and salinity and toxicity of the soil. The most effective method to improve environmental quality is to properly dispose off the solid and liquid wastes adopting suitable strategies and afforestation in one of them for best utilization of industrial/municipal effluents. The experimental site is located in the city of Jodhpur in western part of the state Rajasthan. The climate is arid. The mean annual rainfall is 420 mm and the mean annual pan evaporation is 2025 mm indicating high water deficit in the area. The soil is loamy sand with low soil organic matter and nutrients. The soil is slightly alkaline in reaction. Topography of the land is almost flat.

To study the effect of different types of wastewaters like municipal effluent and industrial effluents (textile and the effluent from iron rolling mills) on tree species and the soil plant interaction, a field experiments was done during 1993-1995, a pot culture experiment for a year

in 1998 and a third during 1998-2002 in lysimeters (Figure 1). These experiences lead development of urban afforestation models to green the Jodhpur city. Seedlings were irrigated at varying levels calculated on the basis of daily requirements of the water i.e., potential evapo-transpiration (PET) of Jodhpur. The levels of irrigation were: soil irrigation with municipal effluent (without plant) @ 1PET (T_1); seedling irrigation with municipal effluent @ 1/2PET (T_2); seedling irrigation with municipal effluent @ 1PET (T_3); seedling irrigation with municipal effluent @ 2PET (T_4) and seedling irrigation with canal water @ 1PET (T_5). Measurements were taken on plant height, collar diameter and biomass at the age of 2 year, 3 year and 4 years after plantation.

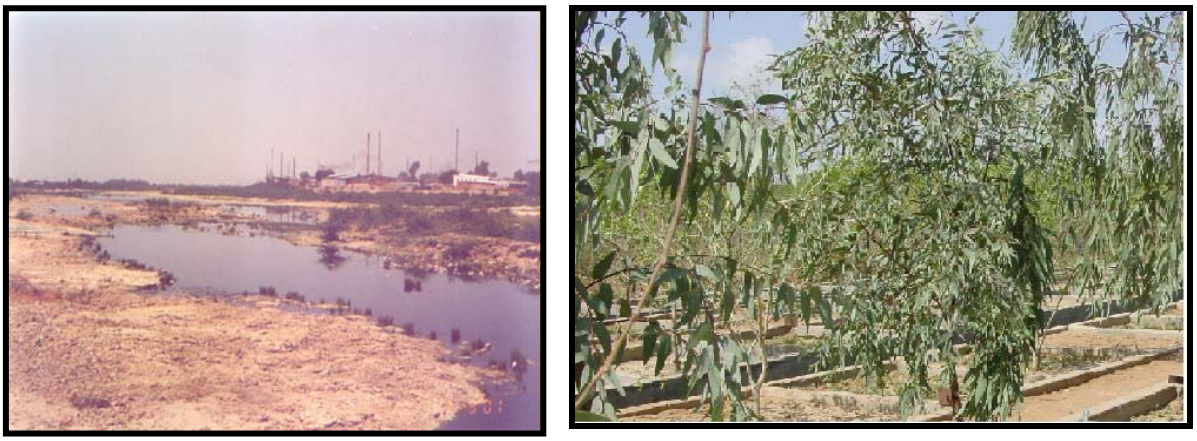

Fig. 1. Effluent discharge causing environmental degradation (left), and established plantation using municipal effluent in in-filled non-weighing type of lysimeters at AFRI, experimental field (right).

1. Prominent beneficiaries/user groups

Municipalities, progressive farmers, State Forest Departments of Rajasthan and Gujarat, non-government organization working in the area and industries.

2. No. of clients to whom technology has been transferred

Municipalities, State Pollution Control Board, Forest Department of Rajasthan and Jodhpur Municipal Corporation are directly associated with this programme and are the main client. The experimental findings have been passed on though discussion, publication media and meetings. This technology has been discussed at many forums such as workshop/conferences, meeting/ stakeholder meetings, public forum, etc.

3. Potential for further dissemination

Increasing population in urban areas and the consequent industrialization draw a large quantity of water and finally provide us a byproduct i.e., wastewater or municipal effluent. Both the need to conserve water and to safely and economically dispose-off this wastewater, make the use of municipal/industrial effluent in tree plantation as a very feasible option in this water scarce dry region. Wastewater reuse reduces fertilization rate and provide a low cost source of irrigation water in dry areas. Trees and shrubs are the better alternative for utilization to municipal effluent because of their high growth rates and potential to produce high biomass on annual basis, ability to sustain very high loading rate, no direct link with food chain and profuse root system to control leaching and salinity & toxicity of the soil.

Scarcity of good quality water in arid areas always pressurized for searching out an alternative source of water for biomass production and meeting the demand of fodder and wood. Application of municipal effluent enhanced growth and biomass of these plants. *E. camaldulrnsis* performed best than other two species with highest mean annual increment. Growth and biomass increased with increase in quantity of municipal effluent irrigation and may be utilized for high loading rates. Biomass productions of municipal effluent irrigated plants were same to the plants irrigated with canal water with double quantity. These results in addition to the findings of pot culture, field experiment and urban afforestation suggest that recycling of wastewater through tree plantations can be an environmentally sustainable and energy conscientious means for producing energy, while restoring degraded habitat of dry areas and when replicated beneficial both environmentally as well as economically.

Paper Published

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D. Economic significance

1. Potential to address livelihood issues and generate additional income

Being a government organization, AFRI works to increase the forest cover and to conserve the biodiversity in arid, semi arid and dry sub-humid regions of western India. Though this experiment showed the potential use of municipal effluent for growing trees in favour of biomass for fuel wood in the thirsty and nutrient poor soil of dry area, but link with livelihood is relatively less. But increased income by way of utilizing fuel wood and improvement in air, soil and water qualities are some of the benefits related to development of livelihood and human resource.

2. Productivity enhancement and economic benefits over replaced technology

Application of municipal effluent had positive influence on the growth and biomass production of the trees seedlings. By way of municipal effluent application one can obtain biomass of 16 -33 tonnes ha-1 at the age of 4 years from *E. camaldulensis*, 13-22 tone ha^{-1} from *A. nilotica* and 15-25 tone ha^{-1} from *D. sissoo*. Growing plants extracted soil nutrients/minerals showing phytoremediation characteristics indicated by comparatively less nutrient status in the bare soil

irrigated with municipal effluent than the planted soils. Application of municipal effluent facilitated the availability of valuable essential soil nutrients as well as water and ultimately biomass and mineral accumulation in plant system in the way of bioremediation. Production of about same biomass for the seedlings irrigated with half quantity of municipal effluent and full quantity of canal water thus saving canal water for other uses. The rate of biomass production was relatively faster indicated by similar biomass production under municipal effluent irrigation at 2PET in 48 months and rainfed condition in 78 months. Thus, it is proposed that this practice can be replicated at local level and subregional level with some adaptation depending upon the chemical composition of the wastewater and utilization of tree products.

Benefits associated with this practice

Environmental	**Economic**	**Social**
Improvement in soil nutrient status and productivity in dry sub-urban areas.	Increased land value.	Improvement in social status and diversion towards children education.
Increased vegetation in diversity.	Increased fuel wood supply at the nearest place.	Increase in social status.
Improved air and water quality.	Increased income.	Improvement in human health.
Increased rate of carbon sequestration in soil as well as biomass.	Increased land productivity and its value. Fuel wood supply.	Easy access to fuel wood.
Increased vegetation cover and reduction in wind erosion.	Increased production and income.	Increase in social status.

3. Impact of the Technology

This technology amply demonstrate that application of highly acidic effluent from iron rolling mills causes plant mortality, because of increased metal uptakes and its toxicity to plants, which should be avoided. Further, use of textile effluent that is alkaline in reaction increase sodium concentration in both plants and soil with simultaneous decrease in magnesium and phosphorus concentration in plants reducing root and shoot growth affecting biomass adversely, which can be avoided. But municipal effluent application produces biomass of 16 -33 tones ha^{-1} at the age of 4 years from *E. camaldulensis*, 13-22 tone ha^{-1} from *A. nilotica* and 15- 25 tone ha^{-1} from *D. sissoo* depending upon quantity of municipal effluent applied. In addition it enhances rate of

carbon sequestration and increased aesthetic values of the area by way of improving environmental quality. Mixing of textile and municipal effluent in 1 : 1 ratio is one option to utilize these two resources.

E. Technology developed by {Name of Scientist(s)/officers(s)}

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