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Eucalyptus plantation in Pakistan: Holistic View of Environmental-Socioeconomic and Medicinal Perspective

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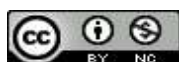
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Abstract

Eucalyptus (family Myrtaceae), an Australian native, is the world's most widely planted hardwood tree. Owing to their outstanding diversity, adaptability, and faster growth characteristics, it is they are considered as a global renewable resource of fiber and energy. In Pakistan, Eucalyptus is most planted tree (over 700 species), adopted in different agro-ecological zones. In one side, Eucalyptus plantation has many established harmful effects on changing the soil chemistry and causes to drop the ground water level, while on other side, it has so many socio-economic and medicinal-use advantages. Considering the all controversies and applied- advantages of eucalyptus plantation, here in this review, we summarized the literature on ecological, socio-economic prospective of eucalyptus in Pakistan. Additionally, study aims to highlight the harmful effects of eucalyptus plantation to environment especially ground water and its impressive medicinal-curative effects to different medical illnesses. We also presented the list of recommendations regarding the government actions toward the future prospective of eucalyptus plantation in the country.



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Introduction

Eucalyptus is one of the most widely planted tree species, with outstanding diversity, adaptability, and faster growth and in-demand industrial wood plant. Eucalyptus species were first introduced to Pakistan in 1967, initially, as an imported, adaptable tree for use in amenity and ornamental plantings in the era of president General Ayoub Khan (1958 -1969) [1]. In start, trial- planting campaigns were conducted in different farmlands of province Punjab and Sindh and following the success of this plantation, Eucalyptus trees were promoted as a major afforestation tree species across country [2, 3].

According to a reported data, about 200 million trees were grown in Punjab in which 2.2% were Eucalyptus trees whereas, 2.7% of 800 million Eucalyptus trees were planted in Khyber Pakhtunkhwa (KPK) that contribute to 470ha of Eucalyptustrees in 28 million new trees in the country in the year 1985 (**Fig. 1**) [4, 5].

United States Agency for International Development (USAID)-sponsored a Social Forestry Project (SFP) was launched in which a large quantity of Eucalyptus tree was planted in farmlands of all four provinces[6].For the purpose to promote the paper industry in Pakistan, in the years 2015-16, KPK government, aimed to increase the forest, a high number of Eucalyptustrees were planted in the whole province under a project title “The Billion Tree Tsunami “and recruited 16000 new employees to plant 9 million fast-growing Eucalyptus trees (**Table 1**) [7, 8].

Herein, we have summarized the available literature on eucalyptus plantation in Pakistan and established controversies on its pros and cons toward economical-benefits and environmental destruction respectively. Furthermore, we highlighted the medicinal applications of eucalyptus plant extract and oils to heal several medical illnesses.

Considering the available evidence of candidate

plant, we anticipate that, current review will add the literature regarding the eucalyptus plantation in the country that will highlight the issues and demand of actions by the concern departments. Additional, study will urge the researchers for further in-depth exploration on elucidating the potential pharmacological importance of eucalyptus extracts and oil.

Effects of eucalyptus on environment

Effects on Soil

Aqueous extract of eucalyptus leaves affects the pH of soil. Studies have proved that due to coarse texture and fewer allelochemicals effect, sand shows minimum pH changes against the aqueous extract of Eucalyptus leaves as compared to other soils where it reduced the pH from 5.6 to 5 [9]. As, Eucalyptus is not a good food nor an adequate habitat for wildlife and has role in decreasing the moisture, and underground reservoirs nutrients so referred to as "Ecological Terrorist" [10, 11].

One of the objections labeled towards eucalyptus plantations is that they may alter the local climate. This is due to their extremely high evapo-transpiration rate, which may result in a lower water table. This high rate of soil water loss is said to have a negative impact on local rainfall levels, perhaps leading to desertification of the area [12]. Adverse effect of eucalyptus plantation on soil nutrients is not universal. It depends mainly on the species, site characteristics, and management practices [13, 14]. Soil and Environmental Sciences Laboratory, N-W.F.P. Agricultural University Peshawar, found that organic matter (O.M) content, electrical conductivity (EC) of soil, phosphorus (P), potassium (K) and micronutrients (Zn, Cu, Fe, and Mn) were low in the different soil samples collected under eucalyptus trees [15].

Table 1: Number of Eucalyptus tree planted in different areas of Pakistan under government record.

Province/territory	Eucalyptus Crops	Land
KPK Province	1.2 billion	Rainy areas
Malakand	14.5 million	Rainy areas
Balochistan	13.7 million	Currently facing an acute water storage
Indus River's bank	3.13 million	Water-logged and saline lands
Chakwal	2 million	Currently facing an acute water storage
Bhakkar	1.5 million	Water-logged and saline lands
Mianwali	0.98 million	Currently facing an acute water storage
Sargodha	0.7 million	Water-logged and saline lands
Shakhupura	0.4 million	Water-logged and saline lands
Motor way, M2	0.2 million	Rainy areas
Haidrabad, Sindh	0.19 million	Currently facing an acute water storage
Dullah	0.043 million	Currently facing an acute water storage

Source: Forestry Statistics of Pakistan (2013).



Fig. 1: A map showing the plantation of Eucalyptus in different areas of Pakistan as per government record.

Effects on flora and fauna

Different plants released phytotoxic compounds that halt the growth of other plants and act as a natural herbicide. The inhibitory effect of eucalyptus on germination of nearby plants is different on different soils and it depends on the physio-chemical properties of soils along with Phosphorus-level. Research reveals that, owing to its allelopathic effect, giant foxtail extract reduced the growth of nearby plants up to 35%. Its phytotoxins have ability to convert into nontoxic substance(s) in the soil where they reduce the seed survival of nearby plants. [16].

Pakistan Forest Institute (PFI) Peshawar investigated that eucalyptus plantations badly affect the crops of wheat and maize in rain-fed areas but in the irrigated field, it halts the growth of sugar cane and wheat [17]. In the chromatographic study, it has been observed the presence of phenolic acid, caffeine acid, flavonoids, chlorogenic acid, Gallic acid, sesquiterpenes, P-coumaric acid, aldehydes, and ketones in the eucalyptus leaves which impose very toxic effects to growth of nearby plants [18]. Eucalyptus foliage: leafy parts of eucalyptus, is the subject of many studies. Presence of phenolic and terpenoid

compounds in the eucalyptus foliage are water-soluble toxins and released by the action of dew, rain, fog or other environmental factors to the other plants [19].

E. globules produced water-soluble chemicals inhibitors such as Caffeic acids, isochlorogenic, P-coumaric, Chlorogenic, ferulic with three volatile inhibitors, Cineole, α -pinene, and camphene that are released into the soil through disused parts of the plant and effect the growth of other plants [20]. Grass growing near to eucalyptus gets also affected due to volatile compounds of eucalyptus such as phenolic acid, benzoic acid, and cinnamic [21].

It has been observed that due to interaction between soil composition and allelochemicals of some eucalyptus species, cause an aqueous extract that leads to decrease the height, fresh root weight, and fresh shoot weight (root/shoot ratio) in surrounding plants species [22]. It is also investigated that the difference in physicochemical properties of soil has different response to eucalyptus extract. Vegetative dry matter production is more in eucalyptus extract-treated plants relative to water-treated plants [23, 24]. **Fig. 2** explains the allelopathy effect of eucalyptus plant on the surrounding species.

Effects on ground water

Ground water is critical to the expansion of irrigated agriculture in many places of the world. Pakistan is the world's third-largest consumer of groundwater for irrigation. The availability of Groundwater has aided farmers in providing food for an ever-increasing population [25]. According to a study by the International Union of Conservation of Nature (IUCN) Pakistan, eucalyptus is reducing underground water and has harmful effects on neighboring plants [6, 26].

China eucalyptus Research Centre (2009) pointed out that the water consumption to synthesize 1 kg dry matter is 1000 L for pine, more than 800 L for coffee, cotton, banana, and Dalbergia respectively, and 510 L for eucalyptus [27]. Theoretically, eucalyptus is a good candidate tree for plantation forests, however, the forestation effect of eucalyptus in China seems to be worse where it causes a significant decrease in ground water level [28]. Pakistan is being dried out due to exotic eucalyptus effect on surface and groundwater. It has been studied that, 64% springs in village Kot and 75% in village Totai in district Malakand, where the water table is decreasing 0.762m per year in both villages [29].

In Pakistan, due to over plantation of eucalyptus and its higher evaporation rate, 6.3 million hectares of soil is barren and waterlogged. According to a study, eucalyptus has high evapotranspiration rate than that any other native species in Pakistan, It further demonstrates that eucalyptus has consumed 12% of the Pakistan's ground water [30]. Parks and Horticulture Authority (PHA) officials declared the decrease in underground water in eucalyptus planted areas. They endorsed the fact that intensity of the effect is less observed in water supplied soil, but extract effect is more significant on fine-textured soil [31]. In a seminar on "Pros and Cons of eucalyptus Plantation in Pakistan" on the awareness of plantation of eucalyptus trees, a senior Punjab Forest department official admitted that "The blunder that was made during its plantation in past years was that eucalyptus saplings were also planted in fertile and water-scarce areas" [32].

Effects on air quality

Punjab Forest Department and Environmental Protection Department has accused that eucalyptus is contributing to environmental pollution in Pakistan. Several studies are focusing to extract natural dyes from eucalyptus and their applications for dying

different materials e.g., cotton and processing the textile industry wastage which contains heavy metals and toxic chemicals that are contaminating the environment [33-35].

Socio-economic advantages of eucalyptus

To cope with the increasing demand of wood, eucalyptus serves as the best alternative of slow-growing species like *Morus* species, *Dalbergia sissoo*, *Acacia nilotica*, etc. Among all eucalyptus species, *E. camaldulensis* and *E. tereticornis* are supposed to be more frequently planted as compared to other eucalyptus species due to their adaptive nature towards diverse ecological conditions in Pakistan [3, 36].

Pakistan has a very small forest cover which is hardly 5%, and large sections without trees. In Pakistan, the main purpose of planting eucalyptus is to meet the demand for timber, biomass, fuelwood, lumber, and to increase forest. Farmer also plants eucalyptus trees for their economic support [37]. eucalyptus is an excellent source of oil for honeybees, birds, human health, and other insects [38, 39]. Pigments extracted from the bark of eucalyptus have average to standard staining properties. Quercetin is a major element of eucalyptus bark and can be used as food dyeing agent [34, 40].

Eucalyptus provides thermal cover, perching, and shelter to birds, animals, roosting [3, 41]. According to the government of Pakistan records, about 200,000 eucalyptus trees are consumed every year by the match industry and in tobacco-curing chambers. In Pakistan, many areas are affected due to the high concentration of salts in groundwater and soil. Studies revealed that eucalyptus is more favorable in waterlogged and saline soil with a growth rate of more than 85% and recommended as the most effective tree in these areas [42]. For this purpose, *E. camaldulensis* is planted in a large quantity to reduced acidity of saline soil in different areas of Punjab province as it has the ability to reduce drainage volume and to tolerate long term salinity [43].

Eucalyptus and human health

Although, there is a lack of enough scientific data to prove that eucalyptus may contain promising health-promoting bioactive compounds but there are many ethno-pharmacological reports about many species of

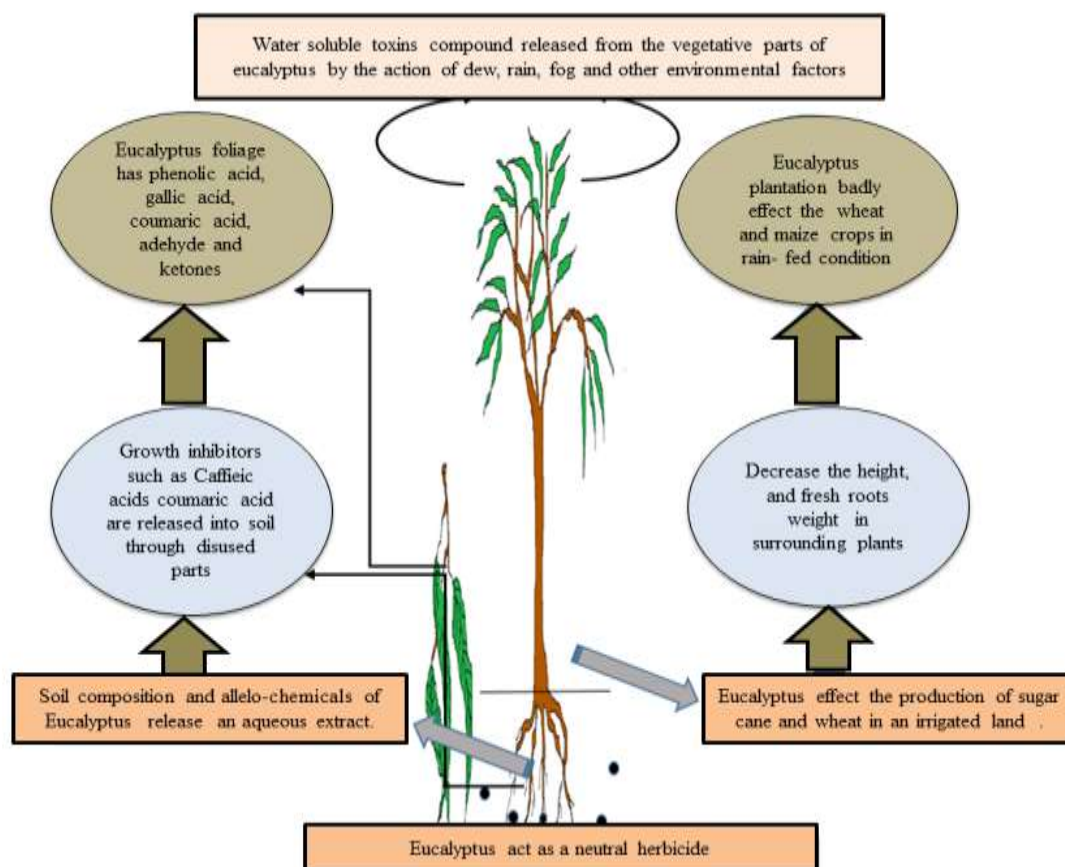


Fig. 2: The allelopathy effect of eucalyptus plant on the surrounding species

eucalyptus. Barrand and his colleagues reported that aboriginal communities of Australia use the eucalyptus leaves and inner bark extract as a medication against many illnesses like flu, colds, fever, aching, sore, internal chest, pain, and headache [35-36]. Study also reported that applying the juice of fresh eucalyptus leaves on the infected skin, heals sores and cuts [38, 44]. Eucalyptus oil is being used in the manufacturing of disinfectants, deodorants, liquid soaps and germicides. Eucalyptus oil also has applications in used in making the antiseptic-inhalants agents [45]. Viscous exudate of eucalyptus parts known as kino is very effective to cure infected skin lesions. Kino solution washes the cuts and open sores [41]. It is also reported that eucalyptus leaves can be used to cure joint and muscle pain by heating them over a small flame and then holding them in contact with the affected body part [44, 46]. Powder of eucalyptus leaves works as a best healing agent, and it may use to fill the tooth cavities or as tooth cleanser [47]. Inhaling the vapors of freshly picked *Eucalyptus* leaves disperse in boiling water is the best remedy of the

chest and respiratory tract infection [48]. It is also reported that eucalyptus leaves are used as a relaxant during childbirth and extract from freshly macerated leaves has been rubbed over the mother breast to stimulate the milk release [44, 49].

Going through the published data, it has been found that eucalyptus oil and extract significantly decrease the proliferation index of several human cancer cell lines and increase their viability [50]. To investigate the pharmacological potential of eucalyptus plant extract against cancer, researchers employ plant extract on the growing cancer cells lines. It has been found that there are many essential oils extract from many species of eucalyptus have ability to inhibit the fast growth of cancer cells and stop cancer progression. For example, in breast cancer cells lines, *Eucalyptus* extract has significantly inhibited the migration invasion of cells and increases the cell death rate (apoptotic index) [51-53]. There are several studies which explored the potential anticancer roles of eucalyptus extract and established the facts that *Eucalyptus* plant extracts are highly bioactive

compounds and hold the great promise of their potential curative effects against many cancers. They added further that, eucalyptus extracts could be potential drugs for different tumors, however, there is need to explore the exact pathways through extensive pre-clinical trials [54, 55]. In a study, it has been shown that *Eucalyptus crebra* is a potential source of essential oil and it need further concern regarding its constituents for various commodities of cosmetics, medicinal and pharmacological attributes [56]. **Fig. 3** gives an understanding about the pros and cons of eucalyptus plant.

Government action plan to eucalyptus issues

Recently, Pakistan parliamentary committee on eucalyptus impact on soil chemistry and environment-related issues observed that 12% of underground water is consumed by eucalyptus. They submit the

reports to the senate for further legislation to impose the legal section to root out the related issues. They further added that “On the surface, we are making green Pakistan while underground dry: considering the eucalyptus plant for greenery on the top of earth and drying out its underground water reserve. According to Pakistan forest institute, the Government should launch schemes to conserve the water and it required practical solid steps to ban on further eucalyptus plantation first. Research and Development Directorate of Forest Department Khyber Pakhtunkhwa, Pakistan conducted a study titled ‘Review of research on the Environmental Impact of eucalyptus’ and concluded that eucalyptus should not be encouraged as an agroforestry species. A massive awareness campaign was launched by the government in farming communities to eliminate eucalyptus trees from farmlands. A recently, 1,150 eucalyptus trees were disappeared in Lahore city by Parks and Horticulture Authority (PHA) that was planted mostly along the city’s roads.

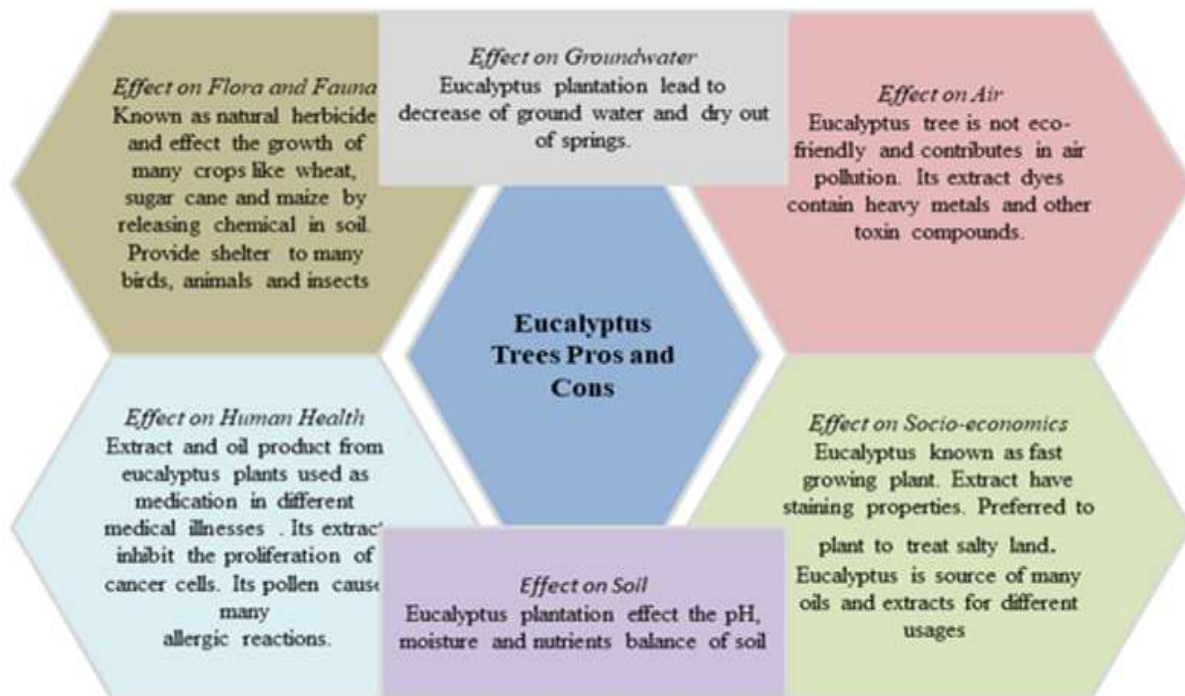


Fig. 3: Understanding about the pros and cons of eucalyptus plant

Concluding remarks and future challenges

Admittedly, eucalyptus plant has many economic-based benefits and counted as major woody tree in the wood industry. However, going through the facts and

reports, it is much deadly to keep growing the eucalyptus especially in irrigated sides, and its forestation without out expert’s recommendations. Continuing its un-planned plantation means disaster in term of sharp decline in ground water level and agriculture yield.

Considering the reported pros and cons of eucalyptus plantation, there are many questions and actions which are highly recommended to address regarding the future outlook of eucalyptus in the country. There is scarcity of data which exclusively revealed the link between eucalyptus tree and its impact on soil chemistry and the environment. Environmental chemist and ecology researchers should design exclusive reach project to disclose the association and its outcomes.

Based on the ecological and economic impacts, respective institutes should design a long-term comprehensive policy regarding the eucalyptus plantation in selective areas upon its need and strict laws by local governments to discourage its plantation as agroforestry on farmland.

It also needs to identify the key bioactive compounds from plants of the very promising genus eucalyptus to test their anticancer properties in clinical trials and to develop novel therapeutic agents for the prevention and/or treatment of cancers. In order to increase forest cover and to meet the fuel wood industry in Pakistan, we are in need to introduce some more ecofriendly and fast-growing species. It is not recommending to elimination of the eucalyptus grown trees on fertile lands instantly before we replace the land with alternative specie. We should promote the plantation of Sukchain, Neem, Amaltas, and Peepul recommended by World Wildlife Fund (WWF) Pakistan.

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Conflict of interest

The authors declare no conflict of interest.

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