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Effects of Exotic Eucalyptus Plantation on the Ground and Surface Water of District Malakand, Pakistan

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ABSTRACT: Vegetation plays a significant role in determining ground and surface water of an area. The present study was aimed to investigate the impacts of exotic Eucalyptus plantation on the ground and surface water in district Malakand (34.50° N, 71.75° E) Pakistan. Two villages (Kot and Totai) were selected randomly for data collection with a sample size of 25% of the population representing each village. The methods used were questionnaire survey, interviews, water table and discharge rate measurement. The results of the study indicated that 64% springs have been dried out so far in village Kot and 75% in village Totai due to high uptake of water. Eucalyptus plantation has adverse effects on ground and surface water. It was found that Eucalyptus has deepened the water table by 0.762m (0.833 yards) per year in both villages as a result the average depth of water table has reached 20.116 m (22 yards) in village Totai and 15.544 m (17 yards) in village Kot. As a result, some springs have become seasonal depending on rainfall. Results of the current study suggest that ground water and surface water resources should be monitored regularly to determine the protection and regeneration of natural forests and better utilization and improvement of marginal and degraded lands. Moreover introduction of new plant species to an area should be made after careful observation of climatic conditions of the area and keeping in mind the possible effects of these species on the environment.

KEYWORDS: Springs, Discharge rate, surface water, ground water, Eucalyptus, Khyber Pakhtunkhwa.

1 INTRODUCTION

According to global standards, forests should comprise 20-25% of total land area of a country. However, in Pakistan forests cover an area of about 4.2 million hectares, which is equivalent to 4.8 percent of the total land area of Pakistan [1] and it is decreasing due to due to continuous cutting of forest trees and commercial overexploitations. The forest cover is unable to meet the growing demand for wood and wood-based products in Pakistan which is the seventh most populous country in the world and the fourth in Asia with an annual population growth rate of 2.1% [2]. To meet the wood consumption demands of increasing population, to increase the forest cover and to support the wood dependent industries, 40 species of Eucalyptus were introduce in the late 19s in Pakistan [3]. In Punjab about 200 million trees were planted mostly on irrigated land, of which Eucalyptus is 2.2%. Similarly in Khyber PakhtunKhwa (formerly known as NWFP) province 80 million trees were raised on farmlands, of which Eucalyptus was 2.7 % [4]; [5]. Among the introduced Eucalyptus species E. camaldulensis was the most wide spread species and adaptable under all agro-ecological zones. Eucalyptus plantations are effective in reducing groundwater level because of high rate of transpiration and evaporation [6]. Zahid et al., [7] concluded that Eucalyptus uses more water than native species Acacia, Albizzia and Azadirachta. Engel et al., [8] showed that E. camaldulensis utilized ground water (67% of its total water use) as well as water from upper vadose zone, which is the source

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of supply to ground water. The increased water use by Eucalyptus depletes ground water and may lead to desertification [9]. In contrary Joshi and Palanisami [10] studied the adverse impacts of growing Eucalyptus in Kolar district of Karnataka state in India. They showed that 20 years of continuous plantation 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 21 villages of Kolar district. The distance between Eucalyptus plantation and freshly dug bore wells had negative correlation with the depth of water table. When wells were located within a distance of 1 Km from Eucalyptus plantations, the water in bore well was reduced by 35 to 42 percent during 3-5 years. The Social Forestry Project in Malakand district was also started in February, 1987 with the objectives that it will contribute to raise the standard of living in the project area by improving the productivity and use of the hill and marginal lands. Till June 2000 large-scale plantations of Eucalyptus camaldulensis were carried out in the Malakand-Dir region on an area of 22,071.29 hectares (54,497 acres) yielding over 14.723 million Eucalyptus trees in addition to other plant species [11].

Malakand district is now suffering from many environmental problems like low water table, micro climate change, soil erosion and dry springs. The key and worth-mentioning contributing factor to the above mentioned problems is Eucalyptus putting livelihood opportunities at grave stake as livelihoods of the people are primarily dependent on water and soil. The objective of the study was to investigate impacts of Eucalyptus plantation on ground and surface water.

2 MATERIALS AND METHODS

2.1 SITE DESCRIPTION

The study was conducted in district Malakand (34.50° N, 71.75° E) Pakistan. The soil of Malakand District is loamy and moist, and is irrigated by the river Swat. Total forest area of Khyber Pakhtunkhwa is 4650561 acres in which Malakand District is contributing 101181 acres in the form of Protected Forest, Communal, Private Plantation and Miscellaneous [12].

2.2 QUESTIONNAIRE SURVEY

Stratified random sampling technique was used to satisfy the results of the study. The whole universe was divided into two strata based on population, education, income, Eucalyptus plants abundance and distribution. From each stratum 25% random sampling was carried out to ensure the authenticity of the results. The questionnaire covered various aspects like impacts of Eucalyptus on the ground water, springs, post and pre scenario of the Eucalyptus, behavior of the people towards Eucalyptus, water table depth, tree distribution, and commercial value of trees in the study area [13].

2.3 DISCHARGE RATE MEASUREMENT

From each village three springs were selected randomly. The discharge rate of springs was measured by diverting the flow through a small opening and the time was noted using a stop watch to fill a container of known volume (300mL and 1L). For large springs, an ordinary tape was used to measure the average width and depth, and multiply this cross-sectional area by the current speed (Q = VA). To estimate the speed, a floating object was thrown into the spring and the time was noted to travel a known distance. Past discharge rate was predicted by taking the marks remained on rocks, an ordinary tape was used to measure the average width and depth, the speed of water was assumed according to the topography of the spring [14].

2.4 SPRINGS POSITION

Global Positioning System (GPS, Garmin with 12 channels) receiver was used to find out the exact position of the selected springs in the study area [15].

2.5 WATER TABLE MEASUREMENT

Water table was measured using an ordinary tape, reaching it down to the water level in wells.

3 RESULTS AND DISCUSSION

3.1 IMPACTS OF EUCALYPTUS ON THE GROUND WATER

The data showed that Eucalyptus has adverse impact on ground water it has lowered the water table by 0.762 m (0.833 yards) per year in the study area. The water table in village Totai has become deeper up to 20.116m (22 yards) while in village Kot the water table got deeper to 15.544m (17 yards). The water table was at depth of 4.572 m (5 yards) before Eucalyptus plantation in village kot but now because of the excessive uptake of water by Eucalyptus plantation the depth of water table has significantly increased to 20.116m (22 yards) (see Fig. 1). On the other hand in village Totai the depth of water table was 3.657m (4 yards) before Eucalyptus which has increased now to 23.774 m (26 yards). The worse water scarcity was observed in 2006-2007 in both villages when wells were dug up to 6.400 m (7 yards).

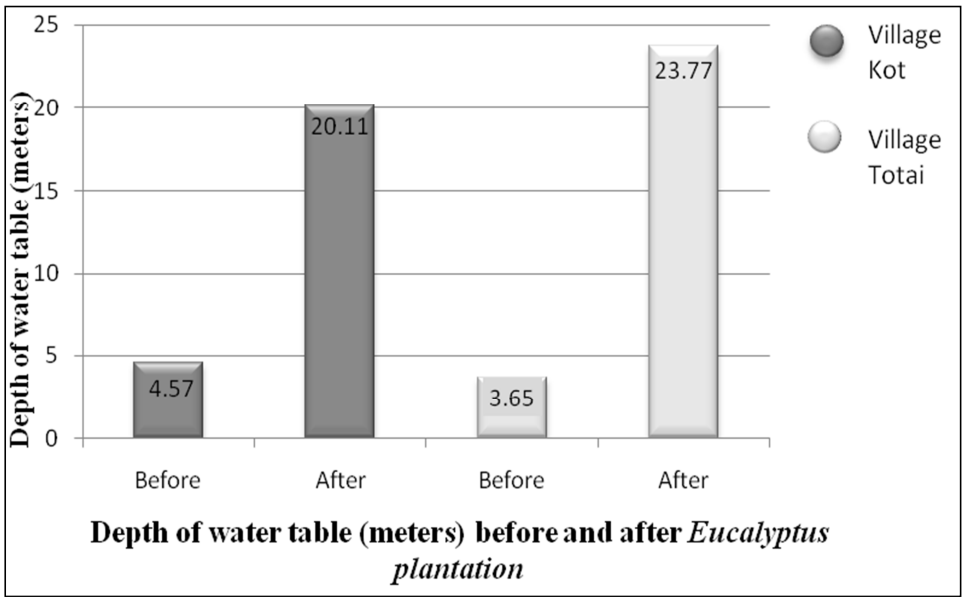

Figure.1 Depth of water table in meters before and after Eucalyptus plantation

Note: 1 yard= 0.9144m or 3ft

3.2 IMPACT OF EUCALYPTUS PLANTATION ON SPRINGS

The expansion of Eucalyptus plantations raises concern over their effect on local water resources [16]. Aforestation can also have the less desirable effect of reducing water yield of an area [17]: [18]. According to Rodríguez-suárez et al., [19] when a meadow pasture is changed to a forestry plantation of Eucalyptus. The annual maximum depth of the water table increased at 2- 2.5 mm/day, while at the same time the catchment discharge rates during summer decreased. The data revealed that 64% springs have been dried out so far in village Kot. There were 22 natural springs before Eucalyptus (as shown in fig. 2) which are reduced to 8 springs and many of them have become seasonal. On the other hand there is a 75% reduction in spring's numbers in village Totai. Before Eucalyptus plantation there were 40 natural springs which are reduced to 10.

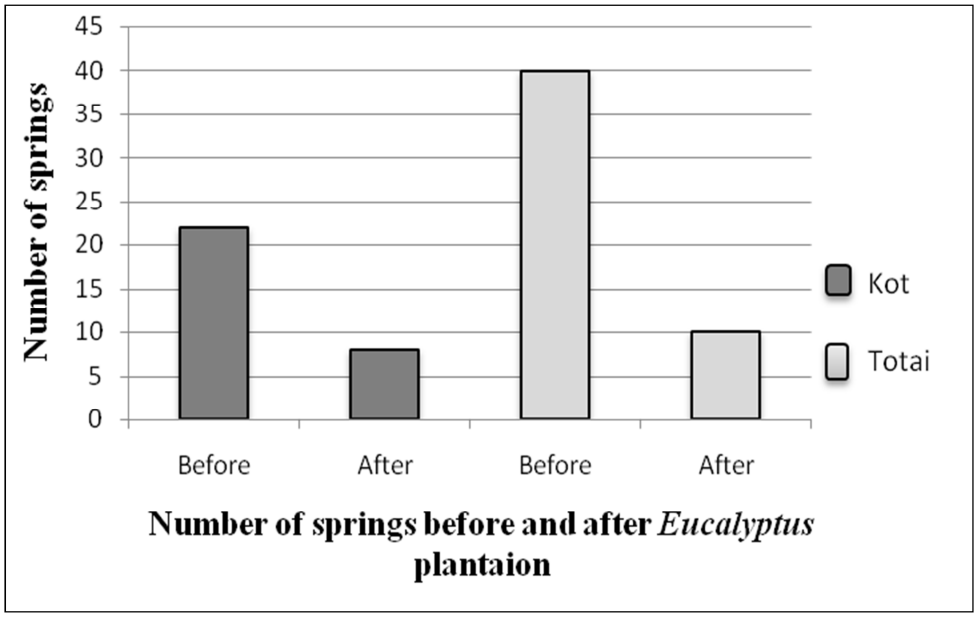

Figure. 2 Impact of Eucalyptus plantation on springs.

3.3 IMPACT OF EUCALYPTUS PLANTATION ON DISCHARGE RATE OF SPRINGS

Eucalyptus has a special root system consists of a shallow rooting system beneath the soil surface and deep tap roots that penetrate deep into the soil reaching the water table. The shallow roots are used to absorb surface soil moisture these extend horizontally to more than 3 to 5 meter. The tap roots can grow up to 9 meters into deeper soil layers to take up groundwater from aquifers. In dry period Eucalyptus shift their water uptake to the deep roots this makes them able to survive and even grow during dry periods [20]. Because of this root system Eucalyptus plantation has adversely affected the discharge rate of natural springs in both villages. Of the three selected springs in village Kot (Figure 3), the discharge rate of first spring has redused to 2.2L/s from 5L/s. The discharge rate of second spring was 1.5L/s which is completely dry now. While spring third has reduced to 0.5L/s from 2L/s. In village Kot 14 springs have been dried out so far and the number of dry springs is incresing at a very fast rate. Hassan and Khan [21] stated that Eucalyptus has caused 80% decreased in the discharge rate of springs in Udigram village Swat, Pakistan from 1995-2000.

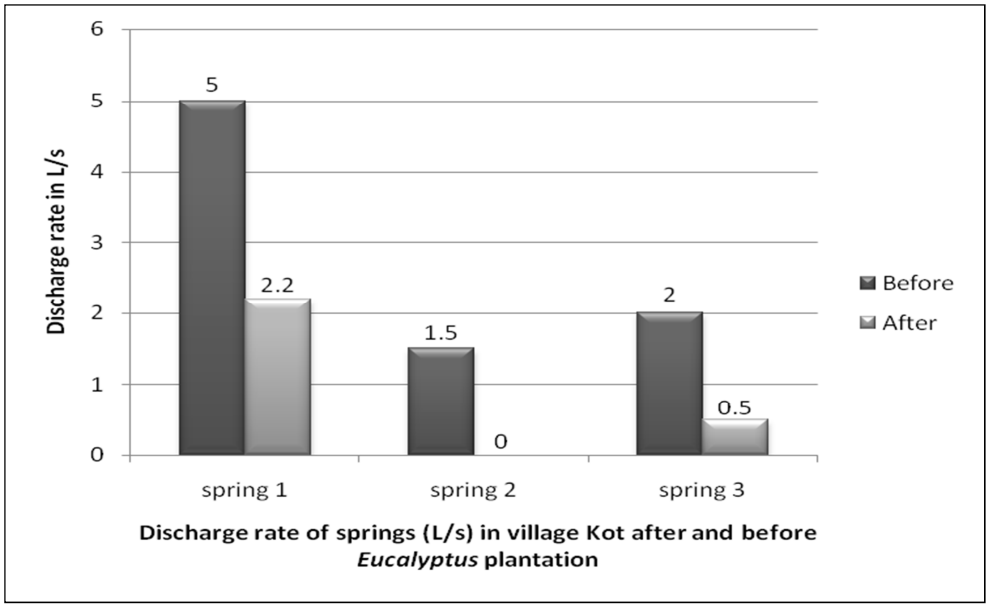

Figure.3 Discharge rate of springs (L/s) in village Kot.

Spring 1 GPS location (N 34o32.386, E 71o43.980)

Spring 2 GPS location (N 34o29.357, E 71o42.829)

Spring 3 GPS location (N 34o29.241, E 71o46.784)

In village Totai the impact of Eucalyptus plantation on springs is much more. The data showed that 30 springs have been dried out. Of the selected springs (as shown in fig.4), spring first has reduced from 3L/s to 0.3L/s while spring second and third with past discharge rate of 1L/s and 1.5L/s are completely dry now.

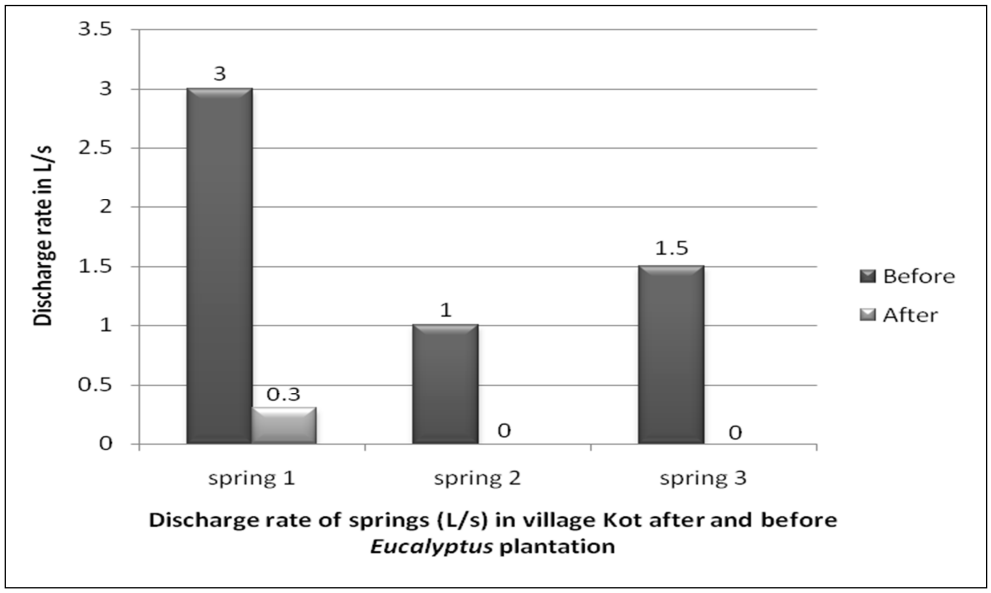

Figure.4 Impacts of Eucalyptus plantation on discharge rate of springs in villgae Totai.

Spring 1 GPS location (N 34o33.702, E 71o44.489)

Spring 2 GPS location (N 34o32.377, E 71o42.966)

Spring 3 GPS location (N 34o32.386, E 71o43.980)

4 CONCLUSION

The results indicate that introduction of Eucalyptus species plantation has adverse impacts on surface and ground water in district Malakand. Eucalyptus has been debated for decades because of its adverse impacts like soil erosion, dryness of springs, lowering water table, competition with crops, micro climate change, affect soil fertility, and consumption of much ground water associated with its high growth rate. Ground water and surface water resources should be monitored regularly to determine the conservation and regeneration of natural forests and better utilization and improvement of marginal and degraded lands. Moreover introduction of new plant species to an area should be made after scientific observation of climatic conditions of the area and keeping in mind the possible effects of these species on the environment. Caution need to be exercised while planning large scale transfer of lands into Eucalyptus plantation.

REFERENCES

[1] GoP, 2005. Economic Survey of Pakistan, Ministry of Finance, Government of Pakistan, Islamabad.
[2] GoP, 2003. Economic Survey of Pakistan, Ministry of Finance, Government of Pakistan, Islamabad.
[3] FAO, 1996. Reports submitted to the regional expert consultation on Eucalyptus. 2: RAP Publication, Bangladesh.
[4] M. Amjad, 1991. Report on tree growth on Farmlands of N.W.F.P. Forest Economics Branch, Pakistan Forest Institute, Peshawar.
[5] M. Amjad, H. Shah, and E. Bakhsh, 1992. Report on tree growth on farmlands of the punjab, forest economics branch. Pakistan Forest Institute, Peshawar, Pakistan.
[6] White, D.A., Dunin, F.X., Turner, N.C., Ward, B.H., Galbraith, J.H., (2002), Water use by contour-planted belts of trees comprised of four *Eucalyptus* species, Agric. Water Manage.53, 133–152.

[7] Zahid, D. M., Shah, F. R., and A. Majeed., 2010. Planting Eucalyptus camaldulensis in arid environment is it useful species under water deficit system. J. Bot., 42(3): 1733-1744.
[8] Engel, V.J., M. Stieglitz, and M. Williams, 2005. Hydrological consequences of Eucalyptus afforestation in the Argentine Pampas. Water Resources Research., 41: W10409.
[9] Zahid, D.M., and A. Nawaz, 2007. Comparative water use efficiency of Eucalyptus camaldulensis. Int. J. Agri & Bio., 09(4): 540–544.
[10] M. Joshi. and K. Palanisami, 2011. Impact of Eucalyptus plantations on ground water availability in south Karnataka. ICID 21st International Congress on Irrigation and Drainage. Oct. 15-23, 2011, Tehran, Iran.
[11] Environmental audit report, 2002. Impacts of Eucalyptus plantations on the environment under the social forestry project Malakand Dir, Pakistan.
[12] DoF, Chief Conservator of forest, 2007-08. Khyber Pakhtunkhwa, Peshawar, Pakistan.
[13] John, H.S., and Lawrence, J.D., 2010. Statistics for earth and environmental scientists, John Wiley & Sons, Inc., Hoboken, New Jersey.
[14] Kjelstrom, L. C., 1995. Methods to estimate annual mean spring discharge to the snake river between milner dam and king hill. Idaho. Boise, Idaho: U.S. Geological Survey.
[15] O. Ovstedal, Kjorsvik, S. N., and Gjevestad, G.J., 2006. Surveying using GPS precise point positioning. Shaping the Change XXIII FIG Congress Munich. Germany. pp: 1–10.
[16] Almeida, A.C., A. Siggins, T.R. Batista, S.Fonseca, and R. Loos, 2010. Mapping the effect of spatial and temporal variation in climate and soils on Eucalyptus plantation production with 3-PG, a process-based growth model. Forest Ecol. Manag., 259: 1730–1740.
[17] P. Lane, A. Best, K. Hickel, and L. Zhang, 2003. The effect of afforestation on flow duration curves. Technical Report 03/13. Cooperative research centre for catchment hydrology.
[18] P. Lane, A. Best, K. Hickel, and L. Zhang, 2005. The response of flow duration curves to afforestation. J. Hydrol., 310: 253–265.
[19] Rodríguez-suárez, J.A., B. Soto, R. Perez, and Diaz-Fierros, F., 2011. Influence of Eucalyptus globulus plantation growth on water table levels and low flows in a small catchment. 396: 321–326.
[20] F. Fritzsche, A. Abate, M. Fetene, E. Beck, S. Weise, and G. Guggenberger, 2006. Soil plant hydrology of indigenous and exotic trees in an Ethiopian montane forest. Tree Physiology 26(8): 1043-1054.
[21] M. Hassan, and S. Khan, 2007. Impact of Euclyptus on the underground water, a case study of udigram Swat valley northwest Pakistan. USEPAM Conference Vietnam.