FORESTRY EFFECT ON DISSOLVED ORGANIC CARBON IN WATERS OF PEATLANDS OF DEOSEI NATIONAL PARK, PAKISTAN

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ABSTRACT: Peatlands are recognized for their ecological significance and vital role in global carbon sequestration and are facing threats worldwide. This research links plantation forestry to water color due to dissolved organic carbon in the waters of the peatlands of Deosai National Park, District Skardu, Gilgit-Baltistan, Pakistan, in the context of water quality and its sustainable conservation. The research question of the study is, do plantation forests enhance dissolved organic carbon concentration? Monitoring of the amounts of dissolved organic carbon in seepage water taken from peatlands and forests in Gilgit-Baltistan's Deosai National Park provides an answer to this question. The results depict a lower concentration level of dissolved organic carbon in forest samples as compared to peatland samples from Deosai National Park waters. Because the litter in mature forest crops is more consolidated, less dissolved organic carbon leaches. Further studies that focus on a more detailed sampling regime for data collection are required.

Keywords: Dissolved organic carbon, sustainable conservation, peatland, forestlands,water quality.

INTRODUCTION

Upland stream systems, that are afforested are likely to show an increase in dissolved organic carbon (DOC) quantity in the water flowing through, following the disturbance of the peat, followed by decreases with tree development and nutrient uptake, and then steady and slow increases given forest maturation (Worrall et al., 2004). In this context, this research focuses on the effects of plantation forests on DOC in the upland of the Gilgit-Baltistan area's waters in Deosai National Park (DNP) with reference to its quality (Zakir, *et al.,* 2015).

Drinking water quality criteria are not met as a result of impact of DOC on water color (Greene, 1987). According to Steinberg (2003), the color of the running water originates in peatland areas where humic chemicals predominate in high amounts of dissolved organic carbon.

According to Danielson (1982), DOC is the amount of organic carbon in a water sample that remains after filtering it using 0.45 µm filter paper. It is used as a general name for a massive range of carbon-bearing molecules of natural organic origin, which include carbohydrates, hydrocarbons, amino acids and fatty acids, and phenolic and humic substances of both macro-molecule and colloid size (Jones and Bryan, 1999).

DOC is made up of several classes for different types of organic compounds found in aquatic environments. An operational categorization for organic carbon is the "dissolved" fraction. Although 0.22 micrometers is also normal, many researchers set the dissolved/colloidal cut-off at 0.45 micrometers.

Temperate peatlands also known as moorland, contain about as much carbon as all living things on earth and contribute 25% of global soil carbon, while in Pakistan (a signatory country to the Kyoto Protocol), peat represents the terrestrial carbon store (Cannel *et al.,* 1993). Peat is basically sedimentary deposits that are organically rich (Bragg and Tallis, 2001). These organically rich deposits are formed where we find the total respiration of producing, consuming, and decomposing constituents of the ecosystem exceeded by the rates of primary productivity (Moore, 1975).

The state between forest and water differs from the uplands to the lowlands and between different forest types. Specially coniferous forests have a higher interception loss than grassland due to their relative smaller size and the surface roughness of their canopies (Forests & Water, 2003).

From the forest floor to the mineral soil, DOC is the main kind of carbon that is transferred. According to Thurman (1985), deciduous litter is a significant source of both DOC and color in runoff and soil water. The majority of DOC production in forested catchments occurs on the higher forest floor. Organic debris is found in almost all streams, but too much of it can have a negative impact on the quality of the water in a number of ways. Some of these elements can seep into rivers and lakes as DOC when water comes into contact with rich organic soils.

Depending on the body of water, a variety of sources contribute to the bulk of DOC. The impact of forestry on DOC seems to be greatest after felling. Generally speaking, falling trees on peaty-mineral soils causes a rise in DOC in stream water that can last for a few years, particularly on a small scale.

The main aim of this study is to test the hypothesis that plantation forests increase DOC (colour)concentrations of upland stream waters in Northern Areas i.e., DNP of Pakistan. The objective is achieved through conducting study i.e., comparison of DOC concentration between forest and peatland sub catchments in Deosai National Park (DNP).

MATERIALS AND METHODS

The study area, the Deosai Plateau, is situated on Gilgit-Baltistan's southeast border. The plateau is situated in Central Karakoram at a central geographic region of 35° 01'N and 75° 40'E, in the far northwestern borders of the Himalayan highlands. Administratively, Deosai National Park falls in Skardu District bordering Astor district in the west Fig .1.

For primary data collection, representative forest and peatland sub-catchment sites were located in DNP. Then water streams were identified for sample collection within these sub-catchment sites. For the study of comparison between forest and peatland DOC concentration seven representative watershed outlets were located in forest and peatland each and six in main streams, grab water samples were collected from these sampling points Fig. 2.

These samples were analyzed in the laboratory to check determinants like DOC, pH, Electric Conductivity and and optical absorbance, the significant differences among means were determined and compared by Mann-Whitney U's test (Wilcoxon-Mann-Whitney test), a non-parametric equivalent to the t-test. A 95% confidence interval was used throughout to decide for significance.

Water samples were taken at the sampling locations using wide-necked, 500 ml acid-washed bottles. These samples were kept in the laboratory's cold room at 4ºC in the dark. Whatman 0.45 µm membranes were used to filter the water.

The Shimadzu TOC-V CPN Series Analyser was used at the geography laboratories of the Universities of the Punjab, Lahore, and Baltistan, Skardu, to analyze these filtered samples for DOC.

Conductivity and pH were measured for these water samples. Following micro filtration, water samples were scanned using a Hach DR4000 Spectrophotometer. The data collected for DOC for peatland and forestland were considered systematically using analytical techniques. The programmes used for statistical analysis were SPSS and MS Excel.

Additionally, water samples were taken from the main stream and subjected to the same analysis methods in order to investigate the dilution impact of DOC in the stream as it flows from peatland and into forest.

Confidence interval limit was found through repeated samples from the main stream, and then datasets were prepared. Tables, charts, and descriptive statistics were used to display the statistical analysis and outcomes of these datasets, which were conducted using statistical tests.

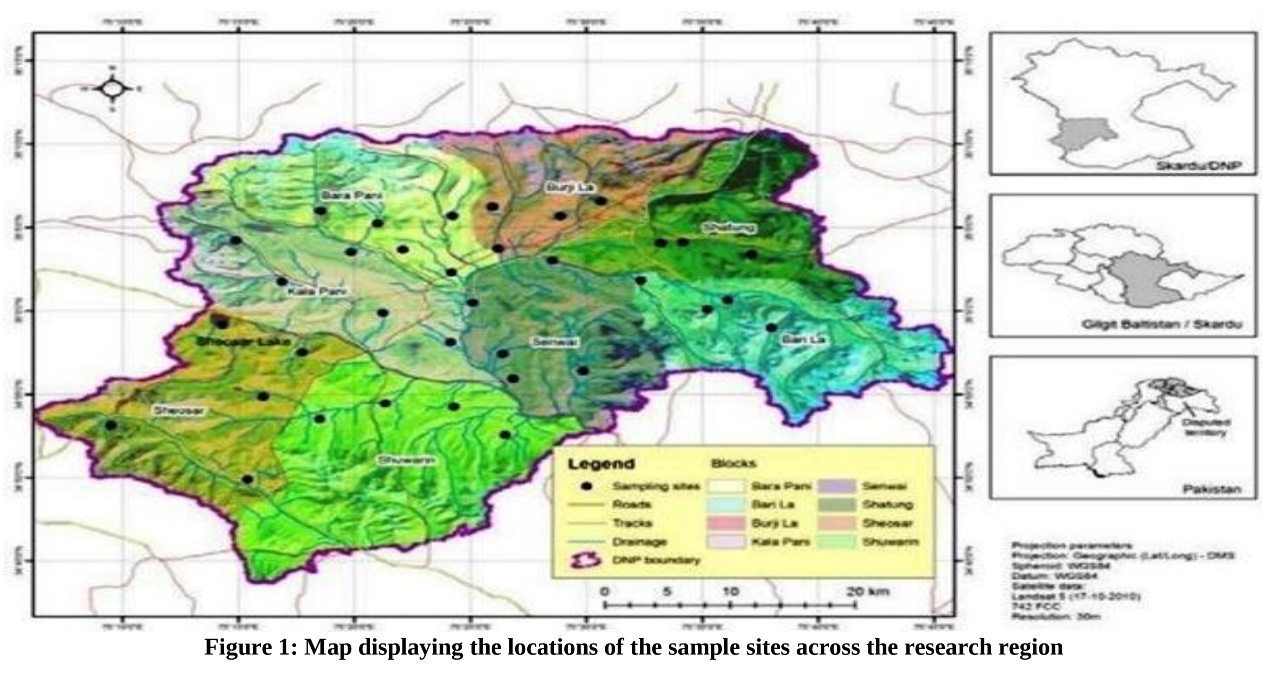

Figure 1: Map displaying the locations of the sample sites across the research region

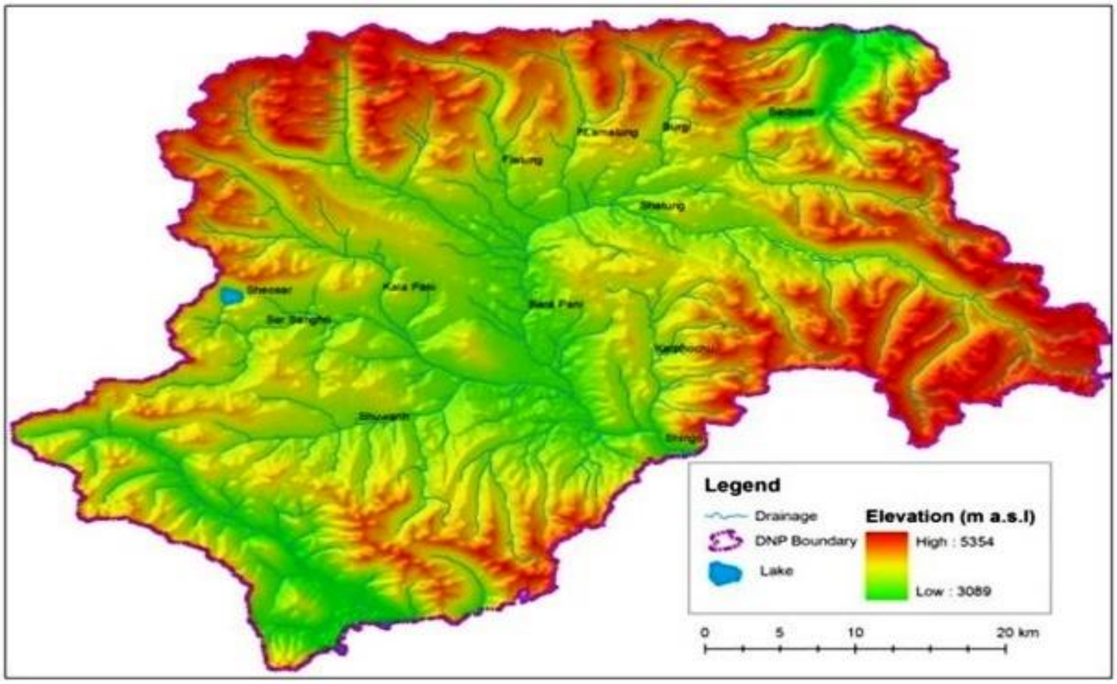

Figure 2: DNP's hydrological map, showing the major lakes, streams, and rivers.

RESULTS

The following sub headings present the results of laboratory analysis of water sample calculations for this study.

1) **DOC comparison:** Figure 1 displays the DOC concentrations of peatland and forest sites during the research period as a function of sample locations. DOC In forest samples, concentrations varied from 3.044 to 21.52 mg l-1, whereas in peatland samples, they ranged from 11.524 to 48.52 mg l-1.

The statistical information for the time frame in which the DOC concentrations at these sites were measured is displayed in Table 1. Given that the non-parametric Mann Whitney U test table value is identical to the lowest computed value U = 1, these results are significant at 95% confidence interval (P = 0.05). This confirms that the DOC value of forest is lower than the peatland value.

Table 1: Data are presented in form of mean, summation, standard deviation and standard error.

Site Name	n	X	∑X	S
Forest	7	7.23	50.62	6.137
Peatland	7	34.351	240.46	13.280
Main stream	6	25.95	155.74	4.628

2) **pH comparison:** Fig. 3 shows pH values of water samples in the study. The comparison shows that value of forest water samples is higher than the peatland except for sample 3. This indicates therefore, that there has been higher pH value in forest than peatland water samples although at sample site 3 the peak of moorland value is higher than the peak of forest value.

3) **DOC- pH comparison in forestland:** The comparison of DOC-pH values of forests over the study period are shown in Fig 4. The graphical results show DOC vs pH in forest water samples.Since DOC mostly consists of acids, it influences pH and functions as a buffer in certain acidic waters.

It is evident from the graphical representation that a relationship is found between DOC and pH. Water is acidic in character whereas as the value of DOC raises pH value downward trend shows that DOC decreases the amount of pH Fig. 4.

4) **DOC- Electric conductivity comparison:** Electric conductivity is represented during the study and is shown in Fig 5. Total dissolved salts (TDS) or total ions dissolved in water are measured by electrical conductivity (EC). The measurement of electric conductivity is done for the water samples, which provides data for more water characteristics. These result is depicted in Fig 5.

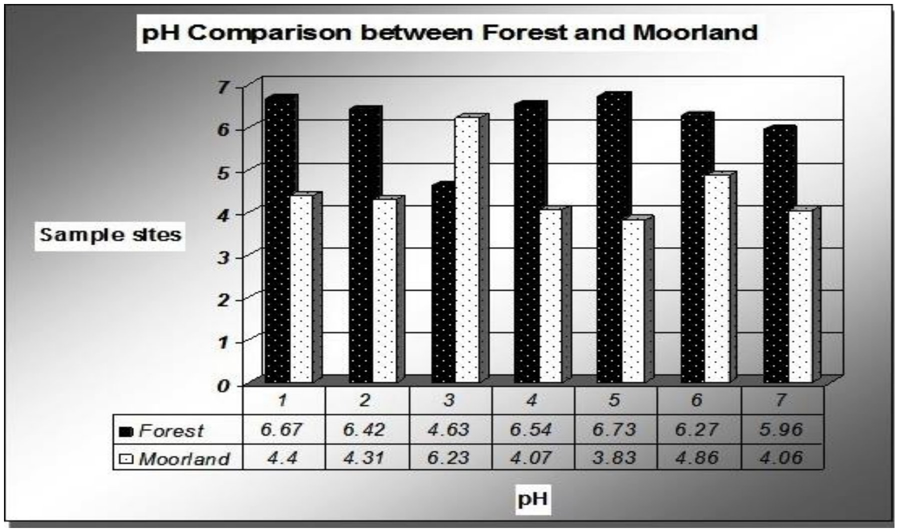

Fig 3: pH comparison between forest and peatland for study period.

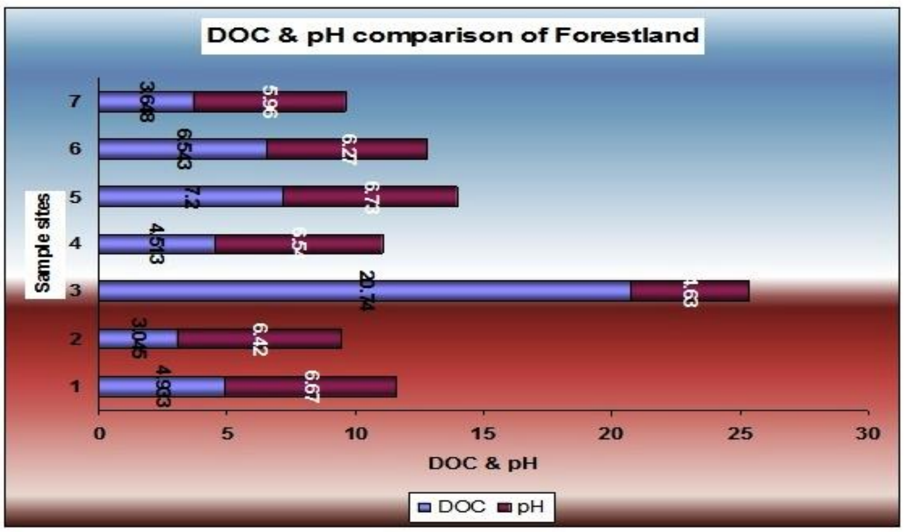

Fig 4: DOC-pH comparison of forest water for study period.

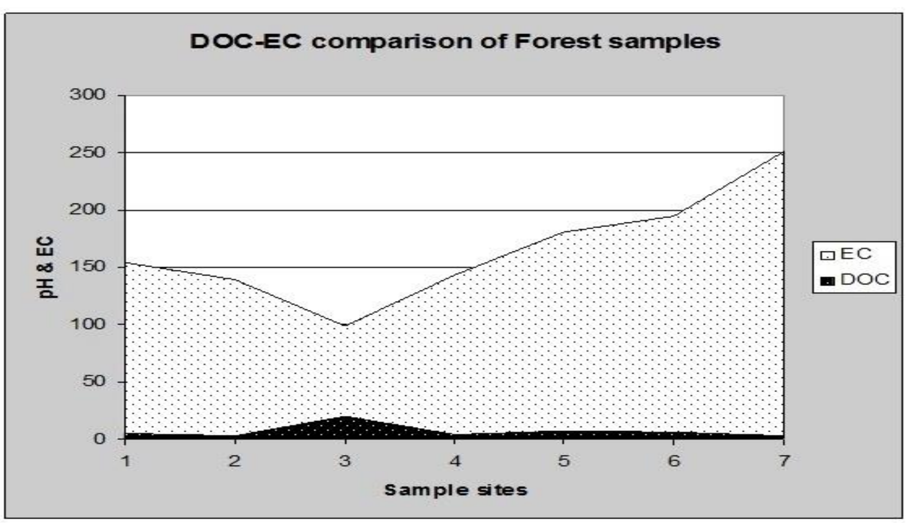

Fig 5: DOC – EC comparison of forest for the study period

5) **DOC – pH comparison moorland:** DOC – pH values of moorland over the study period are shown in Fig 6. These results show that as the DOC values increase, relative pH values decrease for the peatland water samples. But the trend is comparatively smooth as depicted by the forest DOC- pH values.

6) **DOC – optical absorbance comparison:** Optical absorbance was used to measure qualitative variations in DOC. UV and photo-synthetically active radiation penetration is significantly impacted by the light absorption capacity of DOC (Morris et al. 1995). Fig. 7 shows that this variable changed linearly with DOC.

There was no proof that the treatments altered the associations for a particular sample. The high use of water color analysis for DOC concentration estimate in this region is indicated by the excellent correlation between DOC concentration and water color measurement.

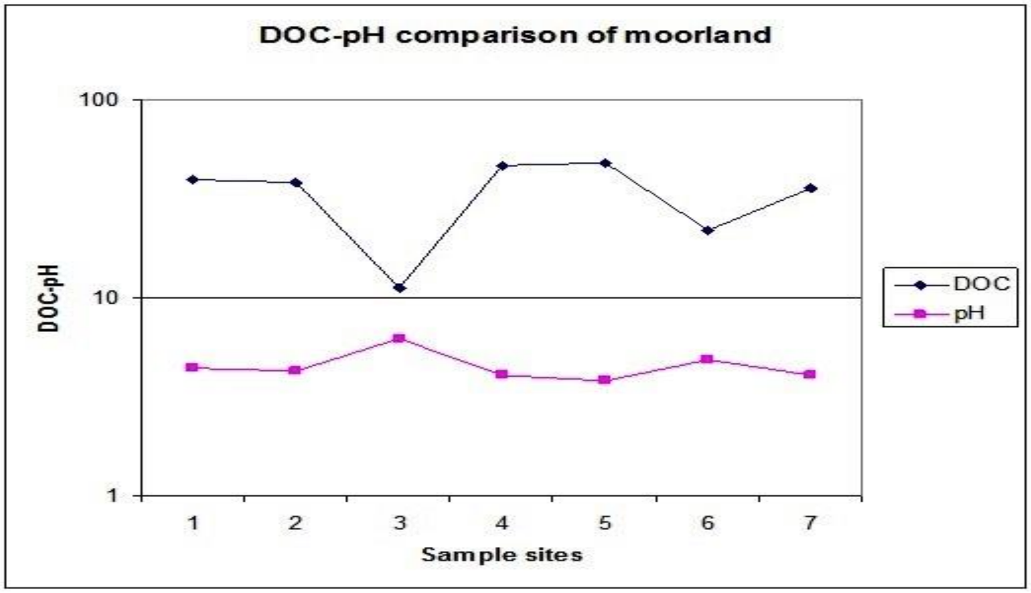

Fig 6: DOC – pH comparison peatland for study period.

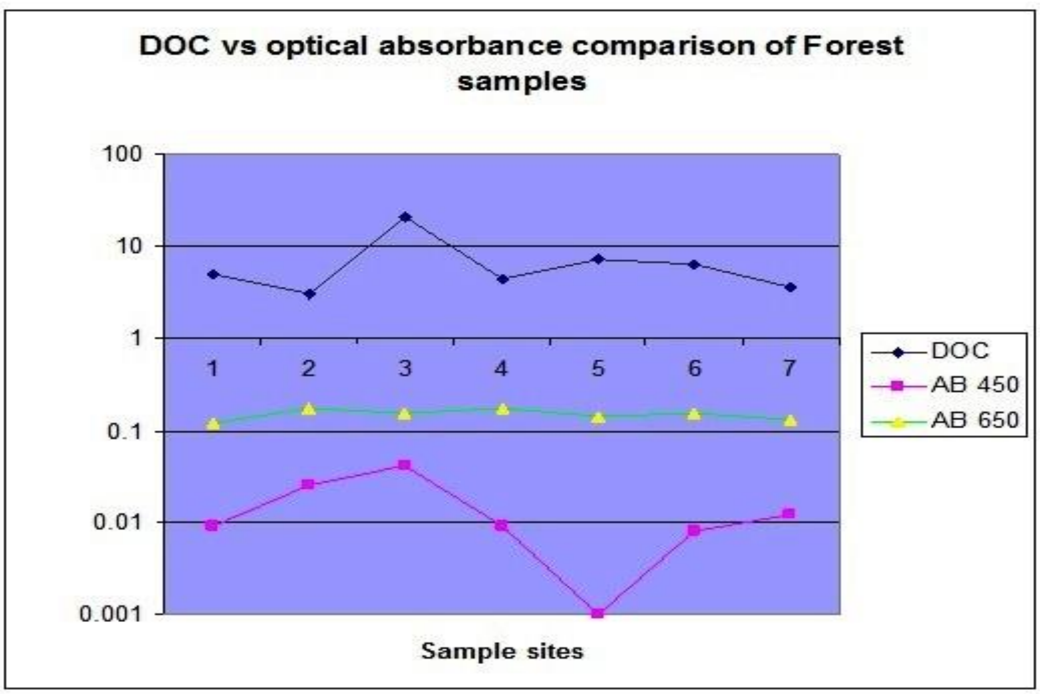

Fig 7: DOC vs Optical absorbance for forest sites for the study.

DISCUSSION

Higher concentrations of DOC from forests have been found in earlier studies, as concluded by Gondar et al. (2005), Kalbitz et al. (2000), and Hongve (1999). Litter is thought to be the primary source of carbon on the forest floor; as DOC is mostly produced from litter, more litter input should result in a higher quantity of DOC. However, the current study's results unequivocally demonstrate that forests have lower DOC concentrations than peatlands, or moorlands (Fig. 2).

The pH value is also found higher in forestland then in peatland / moorland as shown in Fig 3. A study has shown that 80% of annual DOC flux occurred during rainstorms which occurred for just 3% of the time (Charman D., 2002), while analysis of storm discharge events in the study area has confirmed this temporal variability as concluded by Rothwell (2006).

The levels of DOC in the soil water varied significantly across distinct stands due to differences in the litter composition. The amounts of DOC in soil water and via through falls differed from stand to stand. The closeness between the patterns for through falls and above-ground tree litter fall may be explained by the likelihood that variations in DOC concentrations in through falls are connected to canopy coverage (Kline et al. 1968). When a tree is young (such as for the 30-year stand), its canopy coverage will rise; but, as the tree matures, this increase may stop and the tree may even begin to deteriorate.

Increasing concentrations of DOC have been found throughout the late summer and fall months (Grieve, 1990; Scott 1998; Worrall et al., 2002; Freeman et al., 2001). The patterns of DOC flux appear to be related to rainstorms, with much higher flux occurring during and after the event (Cannell *et al.*, 1993). Similarly, this highlights the importance of discharge and event-based research for the assessment of concentration of DOC.

The amount of DOC in soil fluids is significantly impacted by stand age. The relationship between young and old stands—that is, the old stands with the greatest DOC concentrations—is always the most significant. Changes in above-ground tree litter input brought on by stand age and development may account for a portion of the variance in DOC concentrations in soil water (Clarke et al., 2007).

Overall, the research presented suggests that the management of an exotic conifer plantation during the inter-rotation period results in relatively low amount of DOC in stream water and vindicates the use of the current practices in protecting on-site water, soil and nutrient resources (Forsyth, 2006).

This study confirms the null hypothesis that plantation forests catchments produce lower DOC concentration then moorland catchments. It is evident form the study that content of DOC decreases in the mature forests as compared to moorland as water passing through moorland into forests area so mitigation strategies must be chalked out for the sustainable conservation of these peatland areas of Pakistan.

Conclusion: The following conclusion may be drawn from the study's primary findings:

1) The results indicate that there is more DOC in peatland waters than in forest waters, with the greatest amounts being seen in water solutions originating from non-forest areas. But it also signifies the increased danger of acidity of the soil. Dissolved organic carbon concentration in relation to water quality shows that water coming from old and mature stands is lower than concentrations under younger stands due to soil disturbance activities.
2) The DOC concentration enhances the colour effects in the water quality and this reduces the value of water for drinking purposes.
3) Peatland played a major role in DOC production than forests because forests having in land systems reduces the amount of DOC through filtration. Although litter production in the forests may cause higher DOC production leads to the higher pH value creates more acidic conditions but still filtration effect overrides it. Old and mature stands leach low DOC production then young crop due to settled nature of soil activities.

The complete impact of DOC on water quality is not well understood. Furthermore, it is important that this research may be refined through research on the mitigation strategies to other forestry areas and peatlands in Pakistan having different forestry plant species and environmental conditions for environmental conservation and sustainable development.

REFERENCES

Bragg, O. M., & Tallis, J. H. (2001). The sensitivity of peat-covered upland landscapes. *Catena*, 42(2-4), 345-360.

Cannell, M. G. R., Dewar, R. C., & Pyatt, D. G. (1993). Conifer plantations on drained peatlands in Britain: a net gain or loss of carbon?. Forestry: *An International Journal of Forest Research*, 66(4), 353-369.

Cannell, M. G. R., Dewar, R. C., & Pyatt, D. G. (1993). Conifer plantations on drained peatlands in Britain: a net gain or loss of carbon?. Forestry: *An International Journal of Forest Research*, 66(4), 353-369.

Charman, D. (2002). Peatlands and environmental change. John Wiley & Sons Ltd.

Clarke, N., Wu, Y., & Strand, L. T. (2007). Dissolved organic carbon concentrations in four Norway spruce stands of different ages. *Plant and Soil*, 299, 275-285.

Danielsson, L. G. (1982). On the use of filters for distinguishing between dissolved and particulate fractions in natural waters. *Water Research*, 16(2), 179-182.

Forests & Water, (2003). Forests & Water Guidelines. Forestry Commission, Edinburgh. i–vi + 1–66pp.

Forsyth, A. R., Bubb, K. A., & Cox, M. E. (2006). The influence of management on runoff and water quality in a coastal lowland PINUS plantation, Southeast Queensland. In Hydrology and Management of Forested Wetlands, Proceedings of the International Conference, April 8-12, 2006, New Bern, North Carolina (p. 52). American Society of Agricultural and Biological Engineers.

Freeman, C., Evans, C. D., Monteith, D. T., Reynolds, B., & Fenner, N. (2001). Export of organic carbon from peat soils. *Nature*, 412(6849), 785-785.

Gondar, D., Lopez, R., Fiol, S., Antelo, J. M., & Arce, F. (2005). Characterization and acid–base properties of fulvic and humic acids isolated from two horizons of an ombrotrophic peat bog. *Geoderma*, 126(3-4), 367-374.

Greene, L. A. (1987). The effect of catchment afforestation on public water supplies in Strathclyde Region, Scotland. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*, *78*(4), 335-340.

Hongve, D. (1999). Production of dissolved organic carbon in forested catchments. *Journal of Hydrology*, 224(3-4), 91-99.

Jones M.N. and Bryan N.D., (1999)**.** Colloidal properties of humic substances, Advances in Colloid and Interface Sciences, (78), 1-48.

Kalbitz, K., Solinger, S., Park, J. H., Michalzik, B., & Matzner, E. (2000). Controls on the dynamics of dissolved organic matter in soils: a review. *Soil science*, 165(4), 277-304.

Kline, J. R., & Jordan, C. F. (1968). Tritium movement in soil of tropical rain forest. *Science*, 160(3827), 550-551.

Moore, P. D. (1975). Origin of blanket mires. *Nature*, 256(5515), 267-269.

Morris, D. P., Zagarese, H., Williamson, C. E., Balseiro, E. G., Hargreaves, B. R., Modenutti, B., ... & Queimalinos, C. (1995). The attenuation of solar UV radiation in lakes and the role of dissolved organic carbon. *Limnology and Oceanography*, 40(8), 1381-1391.

Rothwell, J. J. (2006). Fluvial export of heavy metals from contaminated and eroding peatlands, southern Pennines, UK. The University of Manchester (United Kingdom).

Steinberg, C. (2013). Ecology of humic substances in freshwaters: determinants from geochemistry to ecological niches. Springer Science & Business Media.

Thurman, E. M. (2012). Organic geochemistry of natural waters (Vol. 2). Springer Science & Business Media.

Worrall F., Burt T. and Adamson J., (2004). Can climate change explain the increases in DOC flux from upland peat catchments, *Science of the Total Environment*, 326 (1-3), 95 –112

Worrall, F., Burt, T. P., Jaeban, R. Y., Warburton, J., & Shedden, R. (2002). Release of dissolved organic carbon from upland peat. *Hydrological Processes*, 16(17), 3487-3504.

Zakir, H., Mirza, S. N., Ashraf, M. I., & Nizami, S. M. (2015). Grassland productivity and carrying capacity of Deosai National Park, Gilgit-Baltistan, *Pakistan. Journal of Agricultural Research* (Lahore), 53(3), 437-452.