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Impacts of Protection on Water Quality, Quantity and Soil of Himalayan Moist Temperate Forests of Galliyat

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Abstract

This paper presents impacts of protection on water quality, quantity and soil of Himalayan moist temperate forest, Galliyat region. Two sites were selected for comparative analysis. Ayubia National Park as protected zone (Z-I, completely protected from all sorts of human interventions) and Guzara forest as un-protected site (Z-II, open to all sorts of human interventions). To determine impacts of protection, altitude, slope and aspects (southern and northern) of both sites were kept constant where as deforestation was taken as the only variable. Data analysis revealed that watersheds of Z-I showed little variation (Q = .0011, .0017 and .0023 m^3/sec) in water discharge rate compared to Z-II (Q = .0047, .0090 and .0092). Similarly, watersheds of Z-II having low vegetation have greater velocity compared to dense vegetation of Z-I. The average sediment concentration calculated from streams of Z-I in April, May and June was 89 ppm where as that of Z-II 206 ppm. Values of other water quality parameters like pH, NO_3, NO_2, conductivity and hardness of both sites were within WHO permissible limits while total dissolved solids and Alkalinity crossed the permissible limits of WHO in Z-II. Soil infiltration capacity of Z-I was greater than Z-II. Other parameters like soil N, P, K values showed little variations.

Keywords: Deforestation, Protection, Water quality, Water quantity.

1. Introduction

Galliyat area lies between 33°-56' and 34°-21' N, 72°-55' and 73°-29' E in Abbottabad (Arshad, 1991). The study area is mountainous having altitude ranges from 7000 to 9500 feet. Due to altitudinal variations the climate of the area does not remain consistent round the year. Main portion of rainfall is received during monsoon from June to middle of September (Khan and Khan, 2002). Being located in the Western Himalayan moist-temperate region, the area is rugged mountainous, consisting of fairly dense forests of conifers, mixed with broad leaved trees and a mixture of luxuriant shrubs and herbs (Shafique, 2003).

Two studies recently conducted revealed reduction in woody biomass at a rate of 4 to 6% per year in Pakistan (GOP, 1992; Hosier, 1993). Fuel wood consumption has been observed more than production in country except in the comparatively low populated Northern Areas; which is more that population growth (3% per year). Based on findings of the two studies, it is expected that woody biomass of the country could be completely vanished within the next 10 to 15 years (IUCN/WWF, 1999). The forest resources are under pressure from deforestation and subsequent land degradation (Ali and Benjaminsen, 2004)

Reduction in potential forest area (decrease of 15%) has been observed due major structural changes in the last 100 year (Ibrar, 2003). Water and appropriate soil are responsible for the sustenance of vegetation and balance of the hydrological cycle. Main purpose of tree cover is to stock up rainfall and further adjust its discharge to springs. Streams and springs carry abundant water in winter whereas it is needed during the cropping season when streams and springs are generally near to the ground or even dried out (Raeder Roitzsch, 1968).

Deforestation brought a lower soil quality in the sites under the study. Soil quality was examined through determination and comparing of some soil physical and chemical properties. Decreasing soil organic matter and aggregate size, increasing soil bulk density, and plasticity index, and changing the base status of the soil

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were few outcomes of the deforestation (Hajabbasi et al., 1997). Deforestation results in carbon loss, so as nitrogen, phosphorus, and sulphur from terrestrial ecosystems. Deforested landscapes soil have been found lower in C and N and somewhat less P and S contents. Reduction of these elements due to forest depletion is most fast in areas having elevated decaying rates, particularly in the tropics and on productive soils. (Vitousek, 1983)

Certainly, in sight of the growing rate of water vulnerability globally, it is important to understand how deforestation may have some benefit in water scarce watersheds. Of course, the apparent benefit of increased water yield may be offset by other significant system adjustments to deforestation (Gordon et al., 2005). Evapo-tranpiration rates changes with deforestation so as infiltration rates and runoff rates (Mustard & Fisher, 2004). Some studies put forward that stream discharge raise by 50% due to deforestation (Mustard & Fisher, 2004).

Deforested results in increased surface water runoff and the faster transfer of surface water results into blaze flooding and more localized floods compared to forested areas (Debebe, 2010). It was evident that loss of vegetation cover contributes to lessen evapo-transpiration, consequently reduces atmospheric moisture and hence adversely influences rainfall levels downwind from the deforested area. Altering soil from parent position by water and wind results in soil erosion. (Debebe, 2010). Forests are important in the Himalayan foothills for catchment's protection (Shinwari, 2009).

In an Australian study plantation catchments were harvested in 2002/3 using legislated BMPs. Streamflows and water quality (turbidity and suspended sediment concentration) were measured between 1999 and 2006 allowing assessments of the impacts of harvesting activities using the BMPs. Results indicate that no significant differences were observed in event mean concentrations of suspended sediment, mean turbidity, or low-flow turbidity or TSS. Analyses of water yields and evapotranspiration have confirmed that annual streamflows in pine plantations vary with respect to annual rainfall and plantation age; the majority of changes being attributable to changes in the baseflow component of total stream flow (Webb et al., 2007). Vegetation cover improves infiltration in a number of ways. Occurrence of refuse and hummus layer reduces surface runoff. Rainfall interception increases the duration of effective precipitation. Likewise, tree density upholds scrap or aggregated structure, which is vital for elevated infiltration (Raeder Roitzsch, (1968). pH values observed in the study area was somewhat acidic below 7.0. Soil organic matter and moisture values were highest in Dungagali where as lowest in Khanaspur, i.e., 3.07%. Sand was found to be the dominant fraction (Ahmed et al., 2004). Deforestation and following tillage practices resulted in almost a 20% increase in bulk density, 50% decrease in organic matter and total nitrogen, a 10 to 15% decrease in soluble ions comparing to the undisturbed forest soil. The tilth index coefficient (average of three depths) of the forest site was significantly higher (0.717) than the cultivated forest (0.633) and the deforested (0.573) sites. Deforestation and clear cutting, of the forests in the central Zagrous mountain resulted in a lower soil quality and thus decreasing the productivity of the natural soil (Hajabbasi et al., 1997). Turbidity increases downstream mainly originated from agricultural areas and erosion from unpaved roads. Previous studies in the river have also indicated that the water quality has been deteriorating as a result of the intensification of the agricultural activities and clearing of forests, as also corroborated by community members living in the upper reaches of the Sondu-Miriu River basin (Masese et al., 2012). Conversion of forest landscape into agricultural one results in reduced hydraulic conductivity. Our results show that the infiltration rate of the forest site was the greatest followed by the coffee plantation site. At the hillslope site it was found that infiltration rate and hydraulic conductivity is lowest (Hanson et al., 2003).

Objective of the study

- To carry out comparative analysis of water quality, quantity and soil in relation to vegetation cover.

Hypothesis

- Deforestation has inverse relation with water quantity, quality and soil

2. Methods

Literature review provides bases for conducting applied research. In this regard,

different reports concerning the study were reviewed. Secondary data regarding the study and area were obtained. Literature review helped in designing of data collection mechanism. Based on analysis of literature review study area was divided into two zones.

- Z-I: Heavy density vegetation zone (Ayubia National Park-Completely protected from deforestation, free grazing, grass cutting and wildlife hunting as per definition of National Park).
- Z-II: Low density vegetation zone (Guzara forest-Un-protected).

Water sampling

Water Quality: Sampling and analysis of all the six streams water were undertaken to identify the differences among the water quantity and quality of protected and unprotected streams and springs.

Sediment Concentration

To determine the sediment load for water quality, runoff samples were collected at the outlet of all sub watersheds having different vegetation density. The samples were brought to the laboratory for determining the sediment yield. For the determination of sediments in the water, 100 cc of water was taken from the sample and filtrate it through the filter paper of known weight. The oven dry weight of the same filter paper was again determined having sediment upon it. The difference between the initial and final weight of the filter paper will be the weight of sediment in parts per million (ppm).

Physical and Chemical Parameters

Physical and chemical parameters like sediments, pH, conductivity, total dissolved solids (TDS), hardness, nitrate and nitrites were analyzed for determining water quality and tracing variation in the data of Z-I and Z-II.

Water Quantity: To determine the variations in quantity of water contributed by each stream and spring (before and after rain) Manning's Equation was used.

$$Q = CAI \{(HR^{0.67} \times S^{0.5}) / n\}$$

where:

Q = Quantity of water in cm^3 / sec

CAI= Cross Sectional Area in cm^2

HR = Hydraulic Radius in cm

S = Sloop in %age

n = Manning's roughness coefficient

and,

HR = CAI/WP = Cross Sectional Area / Wetted perimeter

CAI = Width of the stream in cm and then depth of the stream in cm at certain intervals were taken. Width of the stream × average depth

The tabulated value of manning (n) is available for different type of soil type, terrene and land use type.

Time calculation was made through stop watch for determination of discharge rate of springs.

Soil sampling: Soil samples were collected from six sites, i.e., 3 from Z-I and 3 from Z-II. Samples were stored in polythene bags and analyzed for their N, P, K values.

Chemical Analysis

The N, P, K values of the soil samples was determined through chemical analysis. E. Cond and pH of soil samples was measured by 1:5 dilution methods, Extraction Method used for K and P Mehlich-3, and Extraction Method for Nitrate; 0.01M $CaSO_4$.

Organic Carbon is analyzed through Walkley Black Method (Mikhailova et al., 2007).

3. Results and Discussions

Impacts on water quantity

To determine discharge rate, a total of 6 streams three from Z-I and three from Z-II were selected for comparative analysis.

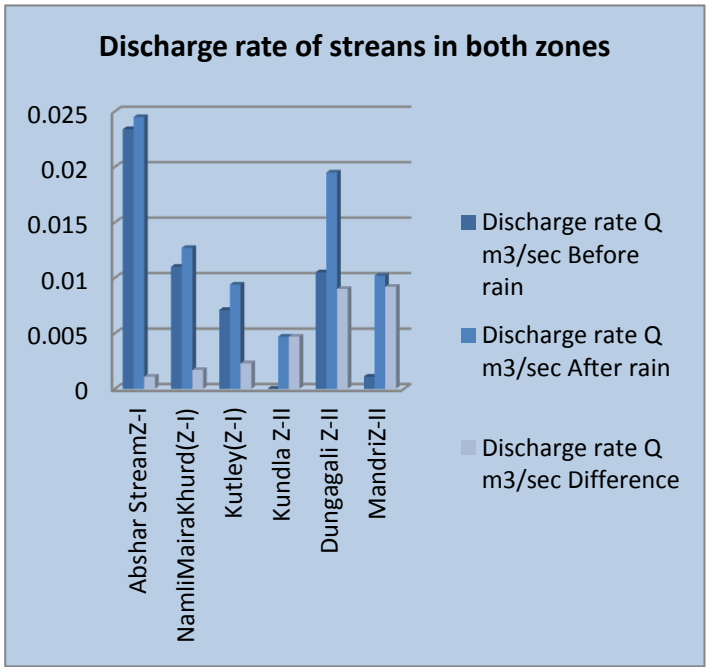
Table 1. Discharge rate of streams and springs from Z-I and Z-II.

Name of streams/ springs	Discharge rate Q m^3/sec		
	Before rain	After rain	Difference
Abshar Stream Z-I	0.0234	0.0245	0.0011
Namli Maira Khurd (Z-I)	0.0110	0.0127	0.0017
Kutley (Z-I)	0.0071	0.0094	0.0023
Kundla Z-II	Dry	0.0047	0.0047
Dungagali Z-II	0.0105	0.0195	0.0090
Mandri Z-II	0.0011	0.0102	0.0092

Data analysis revealed that watersheds of the Z-I showed little variations in discharge rate before and after rain. Abshar stream due to its

dense vegetation has thick canopy, high interception rate, high infiltration rate and hence demonstrated little variations in water discharge.

Fig. 1. Discharge rate of streams in both zones



Thus during rainy season, rain water slowly and gradually moves to stream and spring by sub-surface pathway sustain flow of water through out the years. While in the Z-II stream, it shows relatively more variations in the discharge rate before and after rain due to less vegetation cover. During drought season, sparse vegetation also plays key role in regulating water flow. Thus, vegetation not only sustains water flow but also control peak flow and prolonged base flow before and after rainfall.

Velocity or flow of water (m/sec)

It is commonly observed that watersheds, with low vegetation cover, have faster or greater velocity as compared to watersheds having thick vegetation cover (Jamal and Khadija, 2009). This variation in velocity is because of slope gradients and shape and roughness of stream.

Table 2. Velocity of water in Z-I and Z-II

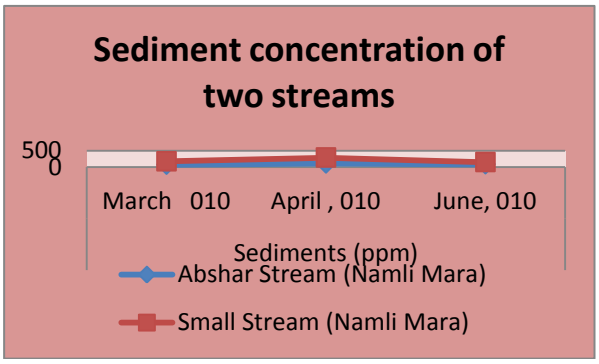
Location	Name of stream	Flow of velocity (m/sec)
Z-I	Abshar Stream (Namli Maira)	2.301
Z-I	Namli Maira Khurd	2.371
Z-II	Dungagali	2.002
Z-II	Road side spring Kundla	0.649

Abshar spring that is covered by dense vegetation, in spite of this, has high flow of water before and after rain as compared to Abshar stream and Kundla spring, due to vertical slope gradients. The second main reason is that whole water of Abshar spring store in a tank and then come out through a pipe. It is commonly observed that store water has high pressure at the out let and thus flow with more speed. Therefore, Abshar spring has high velocity as compared to streams of low vegetation zone.

Water quality analysis

To assess impacts of protection on water quality parameters, 2 streams from each vegetation zones were selected.

Fig. 2. Sediment concentration



Comparing the sediment concentration of two streams of Namli Maira and vegetation condition of these streams' watersheds show that there is a close relation between land use pattern vegetation-cover (forest density) and hydric erosion. Small stream watershed covered by low vegetation, agricultural and pasture land has high discharge as compared to dense forest and thus have maximum chance of erosion. During heavy rainfall soil can easily be driven to streams and deteriorate water quantity and quality. Therefore small stream shows higher concentrations of sediments. While the Abshar stream covered by thick vegetation has less chance of erosion, because vegetation plays a protective role in controlling erosion and sediment concentrations in streams by holding the soil in place.

Table 3. Water quality parameters

Water quality parameter	Vegetation zones			
	Z-I		Z-II	
	Abshar Stream	Namli Maira Khurd	Dungagali	Road side spring Kundla
pH	7.13	7.02	7.71	6.94
NO_3(mg/l)	1.2	0.9	0.5	0.6
NO_2 (mg/l)	0.007	0.009	0.004	0.0
Conductivity (300 µs/cm)	0.28	0.23	1.04	92.0
TDS mg/l	198	177	696	495
Hardness ppm	74	68	365	270
Alkalinity mg/l	65	55	198	155

pH Natural waters range between pH 5.0 and pH 10.0.The pH of all samples is in accordance to this range.

No health based guideline value has been proposed for pH (WHO 2011).

Conductivity expressed in micro Simon per centimeter (µs/cm). Conductivity is a nonspecific parameter, which can be measured to establish pollution zone (Khan and Muhammad, 2003). WHO sets standard for drinking water quality of 300 µs/cm. The values of all samples are within the range.

Total dissolved solids (TDS): It is recommended that T.D.S. should not exceed 500mg/l for public water supplies. The TDS of streams from protected area are under the permissible limits, but the Dungagali sample shows 696 TDS, which is not in the range and very high as well.

Hardness: A guideline value of 500 mg/liter (as calcium carbonate) was established for hardness, based on taste and household use considerations.

Turbidity: Turbidity of water samples of different vegetation zones analyzed was reported as clear.

Nitrate and Nitrites both values were with in the permissible limits of WHO standards of 50 mg/l and 3 mg/l, respectively.

Alkalinity: The Alkalinity values of Z-I streams were in accordance with WHO standards of 150mg/l and the values of Z-II streams are crossing the permissible limits of WHO standards.

The study revealed that there is close relationship between vegetation cover and water quality and quantity. Both quantity and quality of

water resources depend largely on vegetation cover and is being influenced by different land use patterns. Watershed consisting of sparse vegetation have an immense flow for short duration and, when, there is raining. The watershed covered with dense vegetation contributes prolonged flow of stream system because of comprising sub surface and underground flow rather than surface flow. Data analysis revealed that the watershed properties of both areas are impaired. Water quantity of Z-I areas is better than Z-II, during pre- and post-rain analysis. Water quality analysis showed variations specially in TDS (Total dissolved solids) and Alkalinity in Z-II stream but over all variations among Z-I and Z-II watersheds are not very much significant yet can present alarming situation if preventative measures are not being taken before it acquires irreversible status.

Table 4. Soil analysis of Z-I

Sample	pH	E. Cond (us/cm)	K (mg/Kg)	P (mg/Kg)	Nitrate (mg/Kg)	Organic Carbon (%)
Mushkpuri	**6.03**	**33.4**	**16**	**9.2**	**81.153**	**1.8**
Pipeline, ANP	**7.64**	**86.8**	**63**	**9.7**	**241.13**	**3.4**
Kalabagh (Lower)	**6.82**	**49.48**	**48**	**8.7**	**153.21**	**3.4**

Table 5. Soil analysis of Z-II

Sample	pH	E. Cond (us/cm)	K (mg/Kg)	P (mg/Kg)	Nitrate (mg/Kg)	Organic Carbon (%)
Kalabagh	**6.86**	**55.8**	**52**	**8.9**	**153.21**	**2.0**
Dungagali	**7.51**	**51.3**	**24**	**5.6**	**106.15**	**0.4**
Mochidara	**7.71**	**133**	**32**	**7.5**	**194.53**	**1.2**

This study was conducted in Ayubia National Park. It revealed that analysis of high low and moderate density vegetation zone showed the average 36.7, 33 and 28 cm/hour soil infiltration capacity, respectively, showing that the average infiltration rate of soil decreases with the decrease in vegetation density. Decrease in infiltration capacity of soil leads to decrease in ground water storage, an important phase in the hydrologic cycle. (Hussain, 2007).

The analysis of soil samples showed negligible difference of N, P, K values between the protected and unprotected sites. These figures indicate that the physical and chemical properties of both sites are same and formed from the same parent material. So, from this one can easily infer that the only visible factor responsible for the low density of herbs and other forest depletions is tree density and low protection level and not the fertility of the soil.

4. Conclusions

The study reveals that there is a close relationship between vegetation cover and water quality and quantity. Both quantity and quality of water resources depends largely on vegetation cover and is being influenced by different land uses pattern. Data analysis revealed that vegetation regulates the flow of water throughout the year from watersheds and acts as a filter to purify and provides clean water from upstream watersheds to down stream area. Vegetation also reduces soil erosion and plays an active role to decrease the sedimentation in reservoirs. Soil infiltration capacity decreases with the decrease in vegetation cover. Hence protection does play a significant role in protection of water quality, quantity and soil of forests.

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