International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 8 Issue 9 Series I || September 2019 || PP 72-77

Study on the Association of Vegetation with Water Quality of Stream Water of Mussoorie Himalayas, Uttarakhand, India

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Abstract-*Forest land is one of the sources of high quality water. The region of Mussoorie Himalayas is fascinating one and known for characteristic vegetation**. The physico-chemical properties of water are the important determinants of an aquatic ecosystem. In the present investigation, an attempt has been made to study quality of stream water flowing in different seasons through different forest lands of Mussoorie Himalayas in terms of water nutrients (Ca^{+}, Mg^{++}, K^{+}, NO^{-}_{3}).Pearson correlation coefficients (R^2) have been developed. The observation leads to conclude that a number of significant relationships are found to exist between nutrients, Ca^{++}, K^{+}, NO^{-}_{3} on one hand and number of trees on the other hand in respect of pre and post monsoon seasons and different locations. In case of association between Calcium content in water and trees in the post monsoon season at different sites, the value of R^2 coefficient of determination is 0.8458 which means that 84% variation contained in the number of trees (Density/ha) is significant. Alternatively, it may be said that Calcium content is instrumental in bringing out the change in density/ha of trees. In case of premonsoon season, R^2 is .6646.*

I. Introduction

Water is essential for the existence of life on earth. Its quality significantly influences the metabolic activities of all living organisms. It is also a very vital and important recyclable natural resource for providing better living conditions for human beings. When water formed in form of rain or snow in the atmosphere and reaches earth, it is relatively pure (Umamaheshwari, 2016). It passes on through ground vegetation and comes in contact with mineral matter which gets dissolved into it. The quality of water then is changed. Besides, the quality of water is varied due to other factors also such as soil, litter, rocks, environmental parameters, pollutants from industries, agricultural wastes, animal and human activities. These sources introduce harmful sediments, nutrients, bacteria, organic wastes, chemicals and metals into surface water. Of the seventy one percent water covering the planet surface, only three percent is distributed across the forms, glaciers, rivers, lakes and ground water.(Shukla et. al 2018)

On the understanding of previous work done on water quality, it is generally recognized that forest land is one of the main sources of high quality water. The physico-chemical properties of water are the important determinants of an aquatic ecosystem, although they are influenced and modified by climate and riparian vegetation (Hutchinson, 1975).

It is here worth to mention that little work has been done on water quality draining through forested areas of Garhwal Himalayas. The water quality in respect of physico-chemical properties at Mussoorie Himalayas has not been investigated before (Kumar, 1986).A survey of literature on the subject reveals that Osmelon was the first person to emphasize the need for ecological study of Garhwal Himalayas. Dudgeon (1923), Dudgeon and Kenoyar (1925), Puri (1957), Raizada (1959), and Gupta (1966) carried out studies on forest community. Some aspects on ecological problems on fresh communities of Dehradun –Mussoorie belt has been discussed by Saxena and Srivastava (1973). Yadav (1978) studied on chemistry of rain water and its contribution to nutrient export in forests of Central Asia. Mathur (1984) studied on ground water quality pH under different covers at Nilgiri Hills, India. Hopmans (1987) worked on nutrient dynamics of forested catchments in South Australia and changes in water quality and nutrients export. Tiwari and Paliwal (1982) and Singhal and Soni (1989 and 1992). Study on nitrate depletion in the riparian zone and stream channel of a small headwater catchment was done by Cooper (1990). Work on nutrient interception by a riparian forest receiving inputs from adjacentcroplands was carried out by Jordan(1993). Study on Riparian forests as nutrients filters in agriculture watersheds was done by Lowrence(1984). Work on Flow and Nutrient export patterns for an agricultural hill-land watershed was carried out by Pionke(1995).

Overall perusal of the available literature shows that there has been no systematic study on the quality of water draining through forests of Uttarakhand Himalayas, India.

In order to eliminate the lacunae, an attempt has been made in the present investigation to study the effect of vegetation on water quality and thus to pin point as far as possible, the relationship of forest species with stream water flowing through a few selected areas in Mussoorie Himalayas.

Area of Study

The area under study in Garhwal (Uttarakhand) is located from 77^0 east longitude to $78^0.20'$ east longitude and 30^0 north latitude to $30^0.30'$ north latitude with altitude ranging from 330 to 2000 meter from sea level. The situs structure of the study region is a water divide (WD) extending to Mussoorie Cloud End through Chamba, Dhanaulti dividing the water shedsof Aglar, Hiyani, Asan and Song rivers in the Himalayan region. Climatically the region under study is sub-tropical temperate zone. The mean maximum temperature ranges from 16.4^0C to 37.7^0C and the minimum from 1^0C to 6^0C. The rainfall generally occurs from 187.5 to 212.5 mm. The Garhwal region is rich in forests, meadows and marshes with their characteristic plant composition. About 60% is covered by forests and 14% represent cultivated fields.

Selected Sites for Study

The sites for collection of water samples have been chosen on the basis of variation in forest cover after having surveyed the area of Mussoorie-Himalayas. The number of sites selected was ten, viz. Kolhukhet(S-1), Barlowganj(S-2), Bhattafall(S-3), Kemptyfall(S-4), Dhanaulti(S-5), Kadukhal(S-6), Phakot(S-7), Nagani(S-8), Agakhal(S-9) and Hindokhal(S-10).

In all, a total number of twenty six species of trees were collected. A maximum of eight species were collected from site (S-6), seven from the site (S-10) and five species from S-5, S-7 and S-9. The lowest number of species were collected from site S-2.

II. Material and Methods

1. **Floristic Composition-** Studies for floristic composition were made by laying out four nested quadrates in different directions around soil profile of each sampling sites. For trees species, sizes of quadrates laid out were 10 x 10m and 5 x 5m for shrubs and herbs species. Five replications for each type were taken and the average of these have been considered. To determine the density and frequency in these forests, the quadrate method as proposed by Misra (1968) was followed. The value of Crown density was determined with the help of Moosehorn equipment (Garrison, 1949). The trees, shrubs, and herbs were identified on the basis of their diagnostic features. In this regard, the concerning officials of Forest Research Institute, Dehradun, India were consulted to find out about the indentification of species. To determine percentage composition, the number of individuals of a species were divided by total number of individuals of all the species of trees, multiplied by one hundred.
2. **Physico-Chemical Analysis** - The water samples from selected areas during the pre and post monsoon periods were collected in polythene bottles (1 litre each). Three replicate samples were taken from each sample site. The samples were tested for temperature, conductivity, colour turbidity, dissolved oxygen and pH at the field spots. Samples were also frozen in the laboratory until a nutrient analysis could be carried out. Sodium and potassium were determined by flame photometry and nitrate, fluoride, chloride and sulphate were determined by atomic absorption spectro-photometer (Ediger, 1973). Phosphorus content was determined by spectrometer after developing blue- colour (Jackson, 1967). Carbonate, bicarbonate, calcium, magnesium and chlorine were determined volumetrically (APHA, AWWA AND WPCF, 1981). Turbidity of water was determined in terms of Jackson turbidity unit. If the turbidity value exceeded 5mg/l, it was removed prior to determination by centrifugation. The colour is reported in Hazen units.
3. **Statistical Calculations and Treatment** - The statistical treatment was applied to correlate at sampling sites, the different variables drawn from vegetation, litter, soil and water characteristic viz. density/ ha (shrubs and herbs) pH and nutrients (calcium, magnesium, potassium and phosphorus) and a correlation matrix giving bewildering data was computed for pre and post monsoon season.

Correlation Analysis-This statistical analysis was done on personal computer 386 installed at statistical branch, F.R.I. Dehradun. **The analysis was done with the help of statistical package viz SPSS. The program developed was Correlation Analysis. In the present investigation, the method developed by Perason has been used; this gives linear relationship between the variables viz., pH, nutrients and trees only.**

Regression Analysis- When an association is indicated between two variables, the extent of this association may be measured by Regression equations which are mainly used to predict the most likely measure in one variable from the known measurement in another. In simple regression we have only two variables, one variable (as independent) is the cause of behavior of another one (as dependent). By regression, we can interpret what exits physically i.e. there must be a physical way in which independent variable X can affect dependent variable Y. The higher the Coefficiency of determination (R^2), the greater is the accuracy. A number of **regression model equations** were tried and the best suited was picked up. The formats of the models adopted were Logarithmic and Exponential.

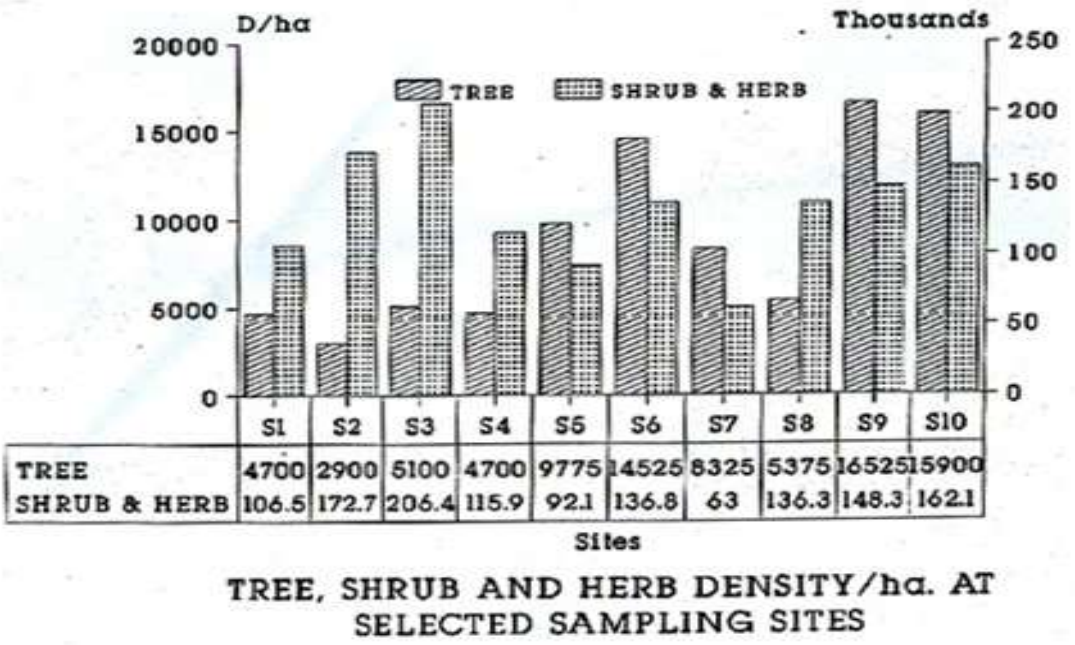
The formats are
(a) Logarithmic Y=A+ B log x
(b) Exponential Y=A X Exp (B X x)

By making logarithmic and exponential equation models, values of R^2 (Coefficient of Determination) have been calculated in respect of different variables like nutrients in water on one hand and trees on another hand in respect of the pre and post monsoon seasons. We have taken into consideration the values of $R^2 >$ 0.33500 only for discussion.

III. Results and Discussion

The maximum percentage composition of different species of trees site-wise are Quercus incana (S-2) 62.07%, Q. dilatata (S-4) 60.01%, Q. leucotrichophora (S-4) 42.39%, Toonaaerrata (S-4) 38.29%, Cedrusdeodara (S-4) 31.96%, Pyruspashia (S-6, 7, 8, 9, 10), Rhodendronbarbatum (S-5), Pinuswallichiana (S-6), Populusciliata and Pyrusmalus (S-6), Benthamidiacapitata and Meliaazedarach (S-9), Shorea robusta, Rhuscontinus, Acacia calechu and Dalbergiasissoo (S-7), T. ciliata and Aeglemarmelos (S-10). Among all the ten sites, the lowest percentage composition was of Erythrimaarborescens (2.5%).

The highest density of trees/ha was found in S-9 (16525) followed by S-10 (15900), S-6 (14525), S-5 (9775), S-8 (8375), S-7 (8325), S-3 (5100), S-4 (4700), S-1 (4700) and S-2 (2900) as shown in Figure.



Figure

Physical and Chemical analysis of stream water during the study period in pre and post monsoon are shown respectively site-wise in table-1 and table-2A and 2B.

Table-1 Physical Analysis of Stream Water During Pre and Post Monsoon

PRE-MONSOON					POST-MONSOON				
S.NO.	**SAMPLING SITES**	**TURGIDITY (JTU)**	**COLOUR**	**TEMP (^{0}C)**	**SEDIMENT CONC. (mg/l)**	**TURGIDITY (JTU)**	**COLOUR**	**TEMP (^{0}C)**	**SEDIMENT CONC. (mg/l)**
1	S-1	1.0	none	24^0C	133.34	2.0	none	22^0C	93.66
2	S-2	nil	none	20^0C	98.58	1.0	none	19^0C	163.92
3	S-3	2.0	none	19^0C	231.39	3.0	none	17^0C	145.23
4	S-4	2.0	none	21^0C	201.81	3.0	none	20^0C	211.47
5	S-5	nil	none	20^0C	25.36	NIL	none	18^0C	91.36
6	S-6	1.0	none	19^0C	28.61	1.0	none	17^0C	27.73
7	S-7	nil	none	22^0C	88.16	1.0	none	21^0C	90.34
8	S-8	1.0	none	21^0C	82.85	2.0	none	20^0C	80.84
9	S-9	nil	none	21^0C	115.07	NIL	none	19^0C	101.81
10	S-10	nil	none	23^0C	28.67	NIL	none	21^0C	23.36

Table-2A Chemical Analysis of Stream Water in Pre monsoon Season

S. NO	SAMPSITES	pH	E.C. (m.mhos/cm)	NO3 (ppm)	Na (ppm)	K (ppm)	Ca (mg/l	Mg (mg/l	MCO_3 (mg/l)	F (ppm)	Cl (ppm)	SO4 (ppm)	BOD (mg/l)	DO (mg/l)
1	S-1	7.71	0.71	0.67	0.19	1.2	93.81	38.14	0.63	2.01	1.30	220.1	1.18	7.5
2	S-2	8.31	0.57	12.03	2.15	1.1	47.21	48.12	0.82	0.12	5.11	54.1	3.17	6.0
3	S-3	7.23	0.99	0.69	0.51	1.4	157.10	72.38	0.62	1.02	0.77	529.2	2.15	7.4
4	S-4	7.25	1.05	2.86	3.21	1.1	108.25	89.25	0.75	0.38	0.49	427.5	2.51	7.1
5	S-5	7.53	1.56	1.21	1.42	1.1	10.58	11.86	0.62	0.41	3.51	15.52	3.58	6.1
6	S-6	8.26	1.02	1.35	3.0	1.2	12.52	11.89	0.72	0.61	4.12	17.18	2.00	6.5
7	S-7	8.21	0.51	nil	0.31	0.79	54.62	32.44	0.69	0.21	0.72	61.59	2.12	7.3
8	S-8	7.71	0.41	0.33	1.31	0.59	53.96	26.99	0.27	0.06	0.82	5.20	1.36	10.1
9	S-9	7.23	0.69	nil	0.25	0.41	14.52	99.89	0.04	nil	0.43	6.81	1.21	8.5
10	S-10	7.63	0.85	8.49	0.38	0.45	15.26	12.58	0.15	0.35	0.55	2.10	2.58	7.5

NOTE: values for Bromide, Nitrite, Phosphate, Phosphorus, Carbonate and Chemical Oxygen Demand (COD) found were to be nil.

Table-2B Chemical Analysis of Stream Water in Post monsoon Season

S. NO	SAMPSITES	pH	E.C. (m.mhos/cm)	NO3 (ppm)	Na (ppm)	K (ppm)	Ca (mg/l)	Mg (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	F (ppm)	Cl (ppm)	SO4 (ppm)	BOD (mg/l)	DO (mg/l)
1	S-1	8.26	0.003	1.59	0.29	0.58	68.90	23.89	0.06	0.56	1.75	2.45	67.80	1.05	9.2
2	S-2	8.51	0.004	6.01	2.80	0.49	70.12	90.51	0.05	0.59	0.29	3.95	187.68	2.45	8.5
3	S-3	8.24	0.006	0.50	0.71	0.52	90.11	53.89	0.06	0.35	0.64	0.84	325.99	1.22	10.8
4	S-4	8.71	0.007	3.10	3.0	0.54	126.12	83.81	0.72	1.41	0.41	0.44	420.80	3.10	9.3
5	S-5	8.81	0.009	0.85	2.83	0.51	14.51	75.51	0.73	1.35	0.53	4.01	13.58	2.86	8.0
6	S-6	9.02	0.008	0.93	2.48	0.52	15.12	9.61	0.04	0.21	0.66	2.91	13.91	1.04	8.9
7	S-7	8.51	0.004	0.36	0.52	0.69	59.91	30.22	0.07	0.86	0.20	0.75	6.28	1.39	7.5
8	S-8	8.81	0.002	0.29	1.62	0.58	58.66	19.98	0.81	0.92	0.06	0.90	6.87	2.11	6.8
9	S-9	8.76	0.004	0.12	1.18	0.31	11.21	90.11	0.71	0.87	0.15	0.61	9.90	2.61	10.5
10	S-10	8.42	0.005	0.42	1.21	0.32	10.31	11.52	0.77	0.71	0.32	0.52	5.50	2.68	9.6

NOTE: values for Bromide, Nitrite, Phosphate, Phosphorus and Chemical Oxygen Demand (COD) were found to be nil.

The observations seem to indicate variations in the parameters during pre and post monsoon seasons. It is evident that both the physical and chemical parameters of water passing through different forest vegetation vary in different seasons.

On the basis of above findings in respect of different sites and pre and post monsoon seasons for the year under investigation it is noted that pH of water was found slightly alkaline in nature and ranged from 7.23 to 8.81. The phosphorus content was nil. The content of the nutrients Calcium, Magnesium and Potassium in pre monsoon period was found higher than what it was in post monsoon at more than half the number of sites with a few exceptions. It was also noted that calcium content in pre monsoon season was slightly less than that in post monsoon season at some sites (S-4, S-6, S-7, S-8). The concentrations in case of potassium and nitrogen was found to be low comparatively.

A number of relationships giving a large data was noted. The overall picture that develops on the study of nutrients analysed in water, soil and litter cannot be discussed in this study for want of space. Our main thrust has been only to study the qualitative impact of vegetation, if any, on quality of water and thus to find out the relationship between vegetation and quality of stream water.

Regression Analysis Observation- The relationship between Calcium, Potassium, Nitrogen content in water and number of trees has been established in pre and post monsoon season. This relation holds good for all sites. The value of R^2 in respect of Ca^{++} and K^+ (Content) in water and density of trees per hectare by using logarithmic model was found equal to .6646 and .3718 in the pre monsoon season Table-3 respectively.

Table-3 Representating significant values of R^2 (Coefficient of Determination)-Regression Analysis

Period	Model	Equation	R^2	Where
Premonsoon	Logarithmic Logarithmic	Y=241.6934-42.2565 log x Y=77.4238-70.9290 log x	.6646 .3718	X=Ca(w) Y=Trees X=K(w) Y=Trees
Postmonsoon	Logarithmic Logarithmic	Y=265.878-49.26632 log x Y= -12.1622-141.1876 log x	.84580 .48850	X=Ca(w) Y= Trees X=K(w) Y=Trees

Y= trees, X= nutrient content in water
R^2>0.35000 has been taken for discussion

By using logarithmic model, the value of R^2 was found to be .8458 and .4885 respectively in post monsoon season in respect of calcium and potassium content with trees (density/ha). The value of R^2 in case of relationship of Nitrogen content in water with number of trees (density/ha) was found to be .4669 by exponential model in post monsoon season.

IV. Conclusion

It has been observed in the present study that there are three different parameters viz. site, season and nutrients. Each one of them forms a group within itself and is significantly different from each other. The findings of the study point out that there is significant association between nutrients (Calcium, Potassium and Nitrogen) in stream water with number of trees. The content of nutrients may influence the density of trees.

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