Assessment of riparian vegetation diversity and its influences on water quality in different land-use practices along Doyang river basin, Nagaland

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INTRODUCTION

Riparian vegetation is the woody and non-woody vegetation of the riparian zone.Riparian vegetation is essential for maintaining high water quality in streams, rivers, lakes, and along shorelines. However, riparian vegetation remains relatively unprotected from poor agricultural practices, residential and commercial construction, landscaping, and logging.Riparian ecosystem is most sensitive ecosystem, veryinfinitesimal changes in the adjacent environment affects the riparian habitat. Agriculture or other anthropogenic activity which are extends to the stream margin are responsible for removal of natural riparian forest (Quinn, 2000). The same phenomenon has been increasingly noticed along Doyang river which is the important river of Nagaland, a state in the north-eastern part of India. In Nagaland, the high prevalence of shifting cultivation, also known as Jhum, forms the major cause of wastelands. With the rapid increase in population, the jhum cycle has now been reduced to 5-8 years and the previously uncultivated and steep land is being taken into the jhum system. This results in accelerating both onsite and off site degradation due to erosion, runoff, nutrient losses, siltation, loss of bio-diversity and disruption in watershed hydrology (IWMP). The state as a whole is a largely mountainous state with agriculture being the most important economic activity in Nagaland. Doyang river is the biggest and longest river and runs along the southern boundary of the state. It is called as ‘Dzu’ or ‘Dzulu’ by the Angamis the native people of Wokha. The main tributaries of the river are Tsui, Tullo and Tishi. The

Doyang Hydro Project is constructed in this river. The Doyang drainage system receives many tributaries from Zunheboto,Wokha and Mokokchung before flowing into Assam and join to the mighty Brahmaputra river of Assam. The Doyang river basin supports floral and faunal diversity maintaining the biodiversity of this region. However because of the changing land use practices, deforestation in the catchment and river banks, shifting cultivation, increasing population and pollution the riparian habitats are threatened as never before. There is urgent need to protect the riparian ecosystem of the Doyang river basin. Apart from the biodiversity and ecological values, the conservation of these habitats is very much directly linked to the livelihood security of the people in this region. In recognition of this, the river basin of Doyang requires the preservation of riparian vegetation along streams and in other sensitive areas in order to protect the water quality and habitat value of these areas. In addition, difference in their effect on riparian stream chemistry, however, is much less clear. To date, there has been no comparative study of vegetation types on the combined effect of all vegetation influences on stream water chemistry of this river. Hence our emphasis will be on the role that riparian vegetation plays in protecting streams from nonpoint source pollutants, togenerate water quality profile that would represent from different land use practicesand calculate the overall Water Quality Index (WQI) of the Doyang River.

• Interdisciplinary relevance

This project can be considered as a multidisciplinary because it includes scientific assessment of the physico-chemical properties of water and phytosociological study of the vegetation and evaluation of the perceptions of people. So it needs a lot of methods from scientific as well as from social framework.Our main focus will be given on the people who are related directly to the river and the riparian vegetation. The tribal in the Doyang riparian area and the fisherman community in the downstream are the major stakeholders. During the survey we have to employ some methodologies like semi- structured interviews, historical timeline and seasonal analysis. Besides these we will interact with sand miners, fisherman, farmers, students, forest guards, local body members, officials, merchants and tourists. Their perceptions will be recorded and opinions of experts of different disciplines incorporated in this study. All these methods employed will be gaining some of the objectives and getting a picture in totality about the structure, dynamics and the human consequences on the riparian vegetation. The secondary information will be collected and incorporated.

• Review of Research and Development in the Subject:

− International status

Riparian areas serve as functional interfaces within landscapes, mediating matter and energy exchange between terrestrial and aquatic ecosystems (Hynes, 1970; Meehan *et al*., 1977; Peterjohn and Correll, 1984; Gregory *et al*., 1987 and 1991). The drainage area bordering the stream is called the riparian zone and is of critical importance to the function, as well as the protection and management of a river (Naiman *et al.,* 1993). They typically occupy a small fraction of the landscape, but they often play a disproportionately important role in controlling water and chemical exchange between surrounding lands and stream systems (NRC, 2002; Burt and Pinay, 2005). Studies show that the riparian zone forms an important sediment sink, where fluvially transported sediment can temporarily be stored. Good riparian vegetation coverage is beneficial in reducing sediment, nutrient and pesticide runoff into creeks and streams (Askey-Doran *et al.,* 1996 reported in Jones *et al.,* 2000); that is why it is considered as most contributing factor in trapping runoff from the catchment to the GBRMP (Jones *et al.,* 2000). Studies show that the riparian zone forms an important sediment sink, where fluvially transported sediment can temporarily be stored. Good riparian vegetation coverage is beneficial in reducing sediment, nutrient and pesticide runoff into creeks and streams (Askey-Doran *et al.,* 1996 reported in Jones *et al.,* 2000); that is why it is considered as most contributing factor in trapping runoff from the catchment to the GBRMP

(Jones *et al.,* 2000).Riparian ecosystems have been reported as some of the most species rich and most productive systems and they are also some of the most sensitive to human influence and potentially threatened ecosystem (Malanson, 1993). According to Qureshi and Harrison (2001), poor vegetation makes riparian areas prone to erosion, bank slumping and weed and pest invasion, adversely affecting water quality and riparian biota and leading to increased downstream flooding and sedimentation. Riparian vegetation has been shown to have a mitigating effect on pollution for receiving bodies of water. The effectiveness of narrow vegetated buffers in mitigating the effects of reduced water quality is well documented in the literature (Thibault, 1997). Cooper *et al.* (1986) found that a riparian forest buffer of only 16 m wide effectively removed most of the nitrate from ground water. Peterjohn and Correll (1984) found similar results. Gilliam *et al.* (1986) studied the sediment transport from soil erosion of agricultural fields and found that 88 percent of the sediment eroded from these fields over a 20-year period had been deposited in the riparian zone (reported in Thibault, 1997). Eighty-nine percent of the nitrogen in runoff was removed by a riparian forest in Maryland (Peterjohm and Correll, 1984 quoted in Thibault, 1997). It was ascertained that the nutrient removal by reducing diffuse-source pollution in riparian forests is ecologically significant to receiving waters. Lowrance *et al.* (1984) considered riparian zone to be important in maintaining stream water quality. A study shows that it can act as a filter for NO_3-N, Ca, Mg, K, and SO_4-S (Lowrance *et al.,* 1984). Riparian vegetation supplies a declining proportion of stream organic matter as streams get larger and aquatic vegetation and other autochthonous sources increase (Cummins, 1975; Vannote *et al*., 1980). Direct and indirect influences of vegetation such as nutrient uptake, organic matter supply, and soil stabilization are strongly related to structural and physiological characteristics of vegetation. As plants vary widely in size, form, growth rate, longevity, and litter quality, their influences on stream water chemistry may range widely as well. This has practical significance because vegetation can be manipulated easily through selection and management. Despite its significance, there have been few direct comparisons of how much stream water chemistry can be managed between herbaceous and woody types of vegetation (Lyons *et al*., 2000). Studies about the quantification the impact of establishment/protection of riparian vegetation on the improvements in water quality are not conclusive (Clausen *et al.,* 2000; Dosskey, 2001).

− National Status

Rivers are considered as the pillars of human civilization all over the world. The presence of irrigated agriculture, towns, cities, and industrial sites along the river bank shows the inextricable dependence of human races on riverine ecosystem. These ecosystems are considered as some of the most sensitive to human influence and potentially threatened ecosystems (Gopal, 1988). In India, floodplain habitats are under threat due to the anthropogenic pressures like overgrazing, deforestation, and land reclamation (Gopal, 1988). River Ganga has lost 80% of its original forest cover in its basin (Smakhtin *et al*., 2006). Riparian forests adjoining stream and river banks have been almost entirely eliminated outside the protected areas (Madhav, 2004). The role of some riparian herbs in soil and water conservation was previously studied by Raju*et al*. (1992, 1996), Ambasht and Ambasht (2003), Srivastava (2007), Srivastava *et al*. (2010), Srivastava and Singh (2011). Riparian vegetation assessment of some of the rivers of India was done by Sunil *et al*., 2010, Conservation of soil, water and nutrients in surface runoff using riparian plant species (Srivastava and Singh, 2012).

Significance of the study

- The results of the study will clearly brought out the need for preparing and implementing site-specific conservation plans for riparian ecosystem;
- The study will form a preliminary assessment of the riparian vegetation against which the results of future monitoring can be taken up; test the sampling and evaluation methods and develop the objectives that will form the basis of a long-term biodiversity monitoring program;
- assist in the selection of sites for future monitoring;
- help in the selection/formulation of appropriate indicators of stream/riparian biodiversity that can be factor in to monitoring, evaluation and reporting mechanisms;
- determine levels of variability within the biodiversity measures that will help to determine the site density required for future biodiversity monitoring and
- efforts will be made by government as well as local levels to prepare and implement both the activities judiciously by involving locals, concerned government officials, experts and NGOs without further delay to prevent further and permanent damage to riparian habitats of Doyang basin after the results has been obtained.

Its potential contribution to knowledge in the field of social relevance or national importance:

Recognition of the riparian corridor as a significant landscape component in maintaining regional biodiversity offers significant advances for resolving issues related to endangered species, cumulative effects, water quality and sustainability.The project will help in developing guidelines and principles for sound scientific and economic management of riparian lands to contribute to the condition and value of waterways in terms of channel stability, water quality, biodiversity and in-stream ecological systems. This project will raise awareness to peoples by providing information on the benefits of having vegetation in the watershed as a way to promote water quality improvement, minimising water quality impacts from shifting cultivation, riparian protection and improved ground cover. Data for water Quality Index (WQI) will be generating from the values obtained from the physico-chemical parameters of water and will help us assess the suitability of water for human use. The output will address the people the suitability of riparian zones to protect water quality and enhancing biodiversity.

Objectives

- To assess the riparian plant diversity in relation to different land use practices.
- To quantify the impact of land use change in water and sediments characteristics.
- To generate a quality of water and sediment profile from different land use along the Doyang River.
- To calculate Water Quality Index (WQI).

Methodology

- Field survey was conducted along the Doyang river. 4 sites will be selected from different land use system viz. 1. Barren land 2. Cropland 3. Woody vegetation and 4. Residential Zone (Anderson *et al*., 1976).
- A floristic survey of trees, shrubs, herbs, grass and aquatic species was performed by least count quadrat method (Misra, 1968). Each species collected will be mounted, labelled, and systematically arranged in a herbarium (Jain and Rao, 1976). Identification of riparian plants will be done with the help of standard literature survey (Kanjilal *et al*., 1934-40; Dutta, 1985 and Cook, 1996).
- Quadrat method was employed for phytosociological characters like Frequency, Density, Abundance, Dominance and Important Value Index following the methods of Curtis and Mclintosh (1950), Stromberg (1995), Misra (1969) and diversity indices will be calculated.
- Physico-chemical paramaters of water samples were analysed on a monthly basis using standard methods (Trivedy and Goel, 1986; A.P.H.A, 2005).
- Soil samples were analysed seasonally for certain selected variables viz; pH (Jackson, 1973), organic carbon (Walkley and Black's rapid titration method, 1934), Nitrate-nitrogen (Grewling and Peech, 1965), Available Phosphorus (modified method of Murphy and Riley, 1962) using spectrophotometer and Exchangeable Potassium using flame photometer (Wilde *et al*., 1979).
- Water Quality Index (WQI) was calculated base on Weighted Arithmetic Index Method.

Year wise Plan of work and targets to be achieve:

1st year: Location of different land use practices sites viz. 1. Barren land 2. Cropland 3. Woody vegetation and 4. Residential Zone; Inventorization and identification of plants found in the study sites.

2nd year: Phytosociological analysis of vegetation including the estimation of the physico-chemical parameters of water on a monthly basis and soil on a seasonal basis.

3rd year: Calculation of Water Quality Index (WQI), Statistical analysis and drafting of final report.

RESULTS AND DISCUSSION

The present final progress report of the project shows the physico-chemical analysis of surface water samples and certain physico-chemical properties of riparian forest soil from eight selected landuse system during the study period from July, 2016- January, 2017.

Description of the study sites: Table 1 illustrates the different land use system selected for the studies. Each site was separated by 2-3 km distances. Location map of the sampling stations is shown in **Fig. 1** and land use/land cover map of the Doyang river in **Fig. 2**.

Sl/no	Sampling station	Station code	Characteristics of sampling station	Coordinates	Elevation (msl)
1.	Station 1	S 1	Upstream forested area with some residential families and ongoing construction of Highway bridge (NH 2).	$26^0$07.298′ N $094^0$23.099′ E	348m
2.	Station 2	S 2	Midstream forested area located around the vicinity of Hydro Electric Dam along the river.	$26^0$13.331′ N $094^0$18.747′ E	314m
3.	Station 3	S 3	Jhum cultivated site located around the vicinity of Hydro Electric Dam along the river	$26^0$14.542′ N $094^0$17.529′ E	335m
4.	Station 4	S 4	Teak plantation site located around the vicinity of Hydro Electric Dam along the river	$26^0$14.214’ N $094^0$16.933′ E	332m
5.	Station 5	S 5	Point of Dam construction site inhabited by some residential families.	$26^0$13.811′ N $094^0$15.779′ E	325m
6.	Station 6	S 6	Residential site (approx.50) along the downstream of the river	$26^0$13.752′ N $094^0$15.068′ E	266m
7.	Station 7	S 7	Abandoned Jhum site along the downstream of the river	$26^0$13.078′ N $094^0$14.661′ E	257m
8.	Station 8	S 8	Downstream forested area	$26^0$12.622′ N $094^0$14.211′ E	243m

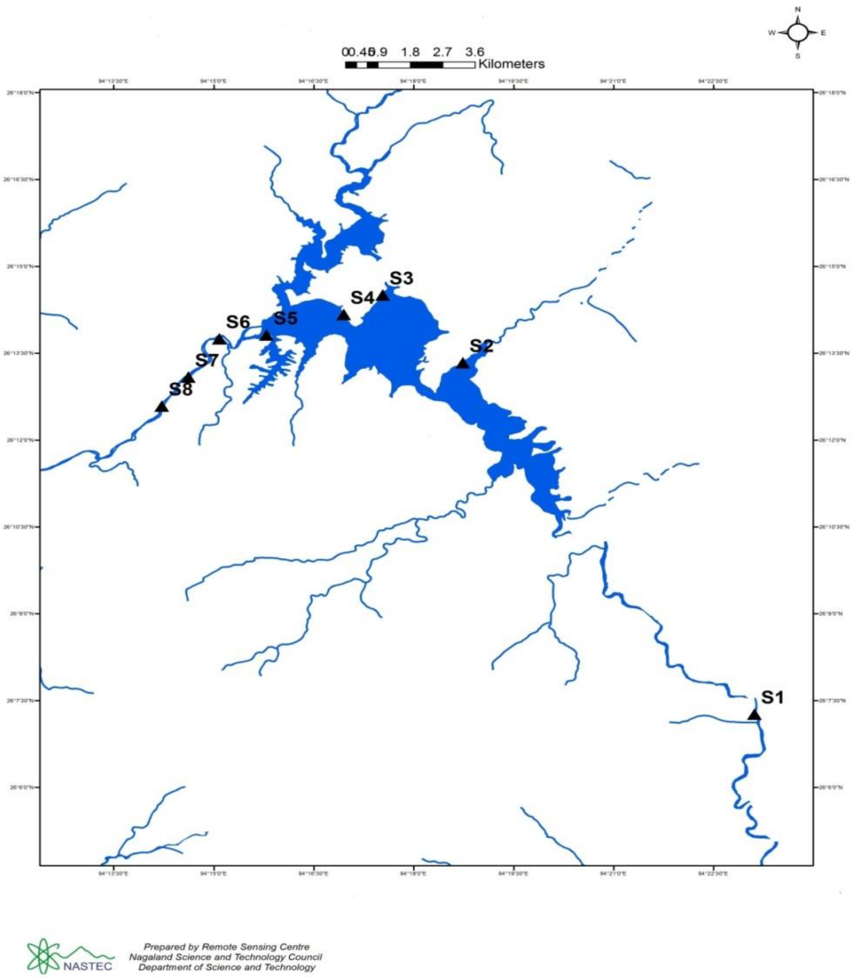

Fig. 1: Map indicating the sampling stations located along Doyang River

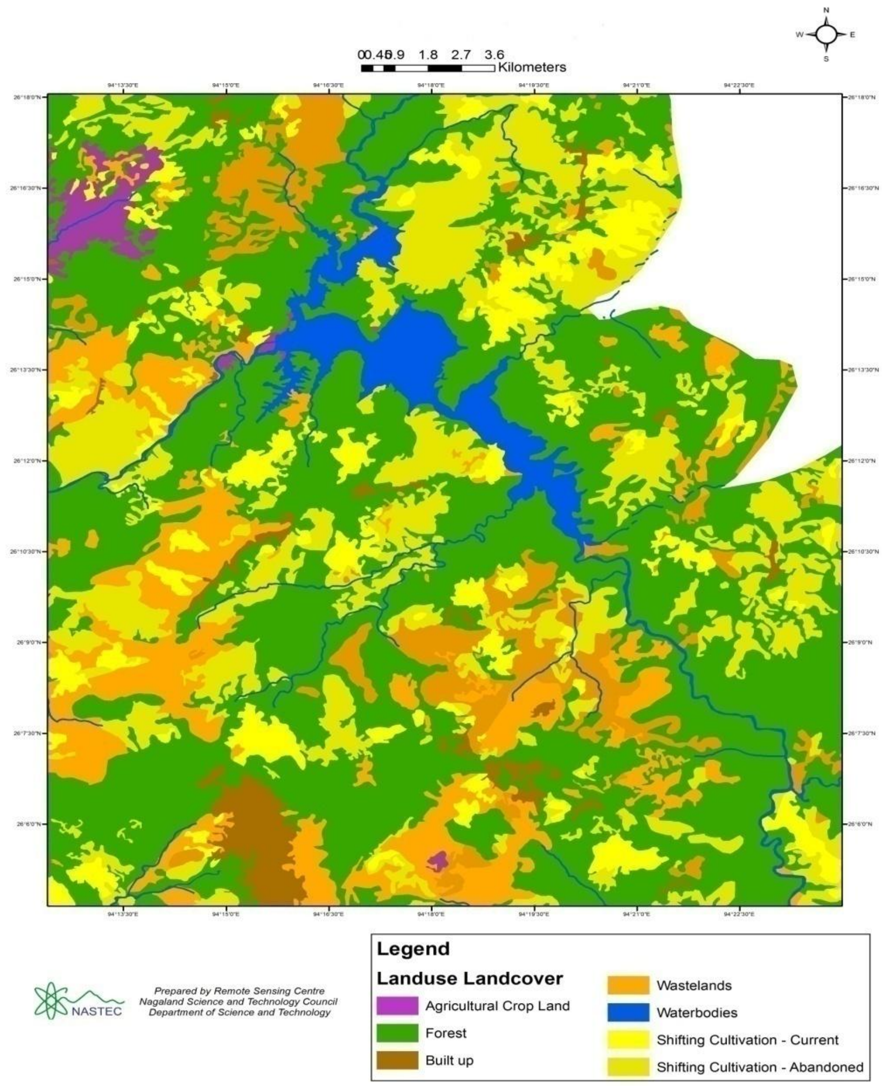

Fig. 2: Map showing the landuse/landcover (LULC) of the study area

Water quality in different land-use practices along Doyang river basin, Nagaland

Monthly and seasonal variation of all the 16 physico-chemical parameters of water samples analysed during the study period (June, 2016 to May, 2017) in different land-use along the Doyang river are shown in **Appendix-I (**monthly variation**)** and **Appendix-II** (seasonal variation). Water temperature is one of the most significant water quality parameter that affects the aquatic animals. Site-4 (29.75^{0}C) recorded the maximum temperature during the monsoon season (June-Sept)with the highest value of 31.33^{0}C in the month of July. The post monsoon season (Oct-Jan)recorded the least value of 18.67^{0}C from site-1.

Freshwaters can vary widely in acidity and alkalinity due to natural causes as well as anthropogenic inputs. The p^H of Doyang river in all the sampling station throughout the study period ranged from 6.4 - 8.97. Site-4 followed by site-5 showed the maximum during the monsoon period (June-Sept) while the minimum value was recorded in site-5 (p^H 6.4) in the month of January. Total alkalinity of water is a measure of its buffer capacity, or resistance to a change in p^H. Its highest value was observed from site-1 throughout the year with a maximum of 161.67 mg/L during the post monsoon season (December). Free CO_2 in site 1(upstream) was recorded at 10.63 mg/L maximum in the month of August and similarly, site 7 (Jhum abandoned site) also recorded a maximum of 10.63 in the month of November. Lowest concentration of free CO_2 (4.03 mg/L) was recorded at site 3 (Jhum cultivated site).

Total dissolved solids (TDS) not only measures the dissolved charged ions but also includes the dissolved, uncharged materials. Much seasonal variation was observed in the concentration of TDS to all the study sites with site-5 showing the lowest value (54 mg/L) in monsoon (Sept). However, there observed a higher average concentration of TDS in site-1 in comparison to all the other sites especially during the pre-monsoon (134.42 mg/L) period (Feb-May). Its lower concentration during the monsoon seasons (June-Sept) in the entire study site could be due to high rainfall.

Conductivity is a measure of electrical conductance of water, and an approximate predicator of total dissolved ions. Significant seasonal variation of electrical conductivity was observed in all the study sites. This variation result mainly from the concentration of the charged ions in solution. The maximum value of conductivity was seen comparatively higher in all the seasons from site-1 with the highest recorded value of 305.53 µS/cm in the month of March (pre monsoon).

Dissolved oxygen (DO) is essential to maintain the higher forms of biological life in water. Site-6 (13 mg/L) in the month of January (post-monsoon) followed by site-2 (12.89 mg/L) in the month of April (pre-monsoon) showed the highest concentration of DO. Lowest concentration of DO was observed in site-6 (4.83 mg/L) in the month of June (monsoon). Significantly lower concentration of DO in some of the sites may be attributed to inputs of organic pollutants, storm water runoff, increased in stream temperature due to clearing of riparian vegetation for agricultural activities and urbanization.

BOD in general gives a qualitative index of the organic substances which are degraded quickly in a short period of time. BOD was found to be highest (4.7 mg/L) in the month of April (pre-monsoon) in site 3 (jhum cultivation) and lowest (0.47 mg/L) in the month of March (pre-monsoon) in site 6 (Residential site)

Chlorides occur naturally in all types of water however its concentration in freshwater remains quite low. Site 1 (upstream) in the month of May (pre-monsoon) showed a concentration of 33.13 mg/L while site 4 (teak site) showed a concentration of 8.99 mg/L in the month of July (monsoon).

Principal cations imparting hardness are calcium and magnesium. It can be temporary harness caused by bicarbonate and carbonates salts of cations and permanent hardness caused mainly by sulphates and chloride of the metals. The maximum total hardness value of 130 mg/L was recorded in site 1 (upstream) in the month of March (Pre-monsoon) and a minimum value of 43.33mg/L from site 6 (Residential site) in the month of September (monsoon). Calcium makes its way into the natural water bodies through leaching from rocks. The concentration of calcium was found to be at the maximum of 31.03 mg/L in site 1 (upstream) in the month of January (post-monsoon) and lowest in site 4 and site 5 in September (monsoon) at 9.35 mg/L.Magnesium concentration remains generally lower than that of Calcium. Its principal source in natural water bodies are various kinds of rocks. Its concentration was found highest in site 1 (15.59 mg/L) in the month of March (pre-monsoon) and lowest from site-6 (4.06 mg/L) in the month of September (monsoon)

Nitrate-nitrogen is the predominant form of dissolved nitrogen in oxygenated waters. It is the form used by aquatic plants for growth. Site-1 showed the maximum concentration of

1.2 mg/L during the pre-monsoon period (March) followed by site-2 and site-6 at a concentration of 1.18 mg/L in the month of June (monsoon). Considerably, lower concentration of 0.29 mg/L was observed in site-3 and site-4 during the month of October (post monsoon).

Phosphorus makes their way easily into the water bodies since they binds preferentially to silts, clay, and organic matter and are the first to erode during rainstorms. Seasonal variation was observed in all the sites with site-1 recording the maximum (0.68 mg/L) in monsoon season (August).

Maximum potassium seasonal concentration of 17.05 mg/L was recorded during the monsoon season from site-8 (downstream) and the least seasonal concentration of 4.14 mg/L was observed from site-2 (midstream).

Sulphur concentration in site-1 (upstream) show the maximum in all the seasons' comparison to all the study sites. The pre-monsoon (Feb-May) recorded the highest value of 24.61 mg/L in site -1.

Water Quality Index (WQI) of Doyang River

Water quality index (WQI) is a single number that expresses water quality by aggregating the measurements of water quality parameters (such as dissolved oxygen, pH, nitrate, total hardness etc.). Assessment of water quality could provide us the overall information on the quality of the water bodies and its potential threat to various uses. Application of WQI is a useful method in assessing the water quality of river. It helps to understand the quality of water at individual sampling stations in order to determine its suitability for various beneficial uses. Calculation of WQI using 'weighted arithmetic index involves the estimation of 'unit weight' assigned to each physico-chemical parameter selected. Different units and dimension of the selected parameters are transformed in a common scale using the assigning units. The WQI value showed a mixed pattern of change in all the seasons in the present study. The WQI calculation of Doyang water samples from all the eight sampling stations for each season are presented in **Appendix-III** .Water quality indexes (WQI) were observed to have positive relation with the seasonal changes. Maximum WQI values were recorded during MON (monsoon) in all the eight (8) stations followed by PRM (pre-monsoon) and POM (post-monsoon). An average value of WQI for all the stations during PRM (pre-monsoon), MON (monsoon) and POM (post-monsoon) were 42.95, 47.13

and 36.66 respectively. This results indicates that in all the sampling stations, the quality of the water samples fall under the class of good water samples (25 < WQI < 50) which is suitable for drinking, irrigation and industrial purpose. In all the stations both PRM (pre-monsoon) and POM (post-monsoon) showed good water quality status. However, in MON (monsoon) water quality showed poor status at stations 2, 3, 4 and 5 which are located around the vicinity of the Hydro-Electric- Dam in the upstream.

Table 2: Sites characteristics of soil sampling stations from different land uses of Doyang River

Sl/no	Sampling sites	Site code	Characteristics of sampling station	Coordinates	Elevation (msl)
1.	Site 1	S 1	Upstream forested area with some residential families and ongoing construction of Highway bridge (NH 2).	$26^0$07.298′ N $094^0$23.099′ E	348m
2.	Site 2	S 2	Midstream forested area located around the vicinity of Hydro Electric Dam along the river.	$26^0$13.331′ N $094^0$18.747′ E	314m
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5.	Site 5	S 5	Residential site (approx.50) along the downstream of the river	$26^0$13.752′ N $094^0$15.068′ E	266m
6.	Site 6	S 6	Abandoned Jhum site along the downstream of the river	$26^0$13.078′ N $094^0$14.661′ E	257m
7.	Site 7	S 7	Downstream forested area	$26^0$12.622′ N $094^0$14.211′ E	243m

Effect of the land use activities along the Doyang riparian zones on Soil Quality

The seasonal variation of different physico-chemical parameters of soil samples from different land use practices along the Doyang River are presented in **Appendix-IV**. Soil pH was found to obtained minimum (5.39) during pre-monsoon at downstream forested site might be due to the presence of slightly higher organic carbon content in the soil.

Organic carbon content recorded a minimum value of 0.77 % at site-6 during pre-monsoon and obtained maximum (2.00 %) during post-monsoon at site-2. Cultivated soils generally have low organic matter content compared to native ecosystems, since cultivation increases aeration of soil, which in turn enhances decomposition of soil organic matter. In addition most of the organic matter produced in the cultivated lands was removed while harvested.

Bulk density was found to be nearly equivalent in all the seven study sites. The top most layers (0-10cm) were found to be comparatively higher than the other corresponding layers.

Soil porosity was found low at site-6 during monsoon and there was a decreased in the porosity of soil as we go deeper

Soil moisture content is affected by both vegetation coveron the soil surface and plant roots in subsoil. All the study sites exhibited high moisture context throughout the different seasons. Higher soil moisture content of 84.81 % was exhibited at site-7 during pre monsoon and lower value (77.14 %) observed at site-7 (forested area) during monsoon because of root absorption. Season of the year have a large effect on soil temperature. Soil temperature was found to be high during monsoon in all the sites in comparison to pre and post monsoon. Site-3 recorded the highest temperature of 31.18^{0}C during the monsoon season and the least of 19.03^{0}C in site-1 during the post monsoon.

Vegetation diversity of Doyang River

Phytosociological analysis of herb, shrub and tree is shown in **Appendix- V**. A total of 16, 17 and 18 species were obtained for herb, shrub and trees belonging to 12, 13 and 16 families respectively. Altogether 51 species of plant were obtained. *Wallichia oblongifolia* Griff. obtained the highest IVI in herb followed by *Phrynium pubinerve* Blume, *Amischoto lypehookeri* (Hassk.) H.Hara etc. In shrub, highest IVI was exhibited in *Premna pinguis* C.B.Clarke followed by *Capparisa cutifolia* Sweet, *Chloranthus elatior* Link etc. In tree layer, maximum IV was recorded by *Sumbavio psisalbicans* (Blume) J.J.Sm. followed by *Syzygium formosum* (Wall.) Masam., *Triadica cochinchinensis* Lour. etc. Various diversity indices for herb, shrub and tree is shown in **Appendix-VI**. It was found that maximum Simpsons' diversity index (D) was recorded by shrub (0.94) followed by tree (0.93) and herb (0.858). It was observed that there exist diverse families in all the species of herb, shrub and trees indicating the rich diverse flora in the riparian forest of Doyang river, Nagaland, North east India.

Summary of the findings

All the twelve (12) physico-chemical parameters of water analysed were within the permissible limits of drinking water given by BIS (2003) and ICMR (1975). From the study of water quality index (WQI) of Doyang River from eight (8) selected sampling stations, maximum WQI values were recorded during monsoon season in all the eight (8) stations followed by pre monsoon and post monsoon. Sampling stations located in the upstream of the river experiences deteriorating WQI due to the presence of Hydro Electric Dam, changing land use practices, increasing settlements and deforestation in the catchment and river banks. However, the Overall WQI values show good water quality status indicating suitability for human uses. The deteriorating condition of water quality in the present study felt the necessity to adopt proper management policy and conservation efforts along the riparian zones of Doyang River. Soil pH was found to obtained minimum (5.39) during pre-monsoon at downstream forested site might be due to the presence of slightly higher organic carbon content in the soil. Organic carbon content recorded a minimum value of 0.77 % at site-6 during pre-monsoon and obtained maximum (2.00 %) during post-monsoon at site-2.

Cultivated soils generally have low organic matter content compared to native ecosystems, since cultivation increases aeration of soil, which in turn enhances decomposition of soil organic matter. In addition most of the organic matter produced in the cultivated lands was removed while harvested. Bulk density was found to be nearly equivalent in all the seven study sites. The top most layers (0-10cm) were found to be comparatively higher than the other corresponding layers. Soil porosity was found low at site-6 during monsoon and there was a decreased in the porosity of soil as we go deeper. Soil moisture content is affected by both vegetation cover on the soil surface and plant roots in subsoil. All the study sites exhibited high moisture context throughout the different seasons. Higher soil moisture content of 84.81 % was exhibited at site-7 during pre monsoon and lower value (77.14 %) observed at site-7 (forested area) during monsoon because of root absorption. Season of the year have a large effect on soil temperature. Soil temperature was found to be high during monsoon in all the sites in comparison to pre and post monsoon. Site-3 recorded the highest temperature of 31.18^0C during the monsoon season and the least of 19.03^0C in site-1 during the post monsoon. A total of 16, 17 and 18 species were obtained for herb, shrub and trees obtained respectively. *Wallichia oblongifolia* Griff. obtained the highest IVI in herb followed by *Phrynium pubinerve* Blume, *Amischoto lypehookeri* (Hassk.) H.Hara etc. In shrub, highest IVI was exhibited in *Premna pinguis* C.B.Clarke followed by *Capparisa cutifolia* Sweet, *Chloranthus elatior* Link etc. In tree layer, maximum IV was recorded by *Sumbavio psisalbicans* (Blume) J.J.Sm. followed by *Syzygium formosum* (Wall.) Masam., *Triadica cochinchinensis* Lour. etc. Various diversity indices for herb, shrub and tree showed that there exist diverse families in all the species of herb, shrub and trees indicating the rich diverse flora in the riparian forest of Doyang river, Nagaland, North east India.

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Appendix-I

Monthly variations of sixteen physicochemical parameters of water samples from eight selected sampling station along Doyang River.

1. TDS (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1 **S.E (±)**	80.67 0.33	80.67 0.33	79.67 0.88	79.33 0.33	85.33 0.67	108.33 0.88	121 0.58	131.33 0.67	132.67 0.88	162.67 0.88	122 0.58	120.33 0.33
S 2 **S.E (±)**	74.67 0.33	67.33 0.33	68.33 0.67	65.67 0.33	67 0.58	74 0.58	75.67 0.33	82 0.58	85.33 0.88	96 0.58	102.33 1.15	108 0.58
S 3 **S.E (±)**	88.67 0.33	61.33 0.33	66.33 0.33	65.33 0.33	62.67 0.33	73 0.58	71.67 0.33	80.67 0.33	81.33 0.88	88 0.58	90.33 1.15	97.33 0.67
S 4 **S.E (±)**	87.33 0.67	56.67 0.88	64 0.58	60 0.58	60.67 0.33	69.33 0.33	73.67 0.33	82.33 0.33	80 0.58	84 0.33	88 1	95 0.33
S 5 **S.E (±)**	85.67 0.33	54.67 0.33	61.67 0.58	54 0.58	57.67 0.33	72.33 0.33	70.67 0.33	82.67 0.33	81.67 0.33	87 0.58	85.33 0.58	91.67 0.88
S 6 **S.E (±)**	86.67 0.33	66.67 0.33	62.23 0.33	65.67 0.88	67.67 0.33	78.67 0.67	82.67 0.33	84 0.58	82.33 0.33	84.33 0.33	83.33 0.58	86 0.58
S 7 **S.E (±)**	87 0.58	65.67 0.33	63.33 0.88	67.33 0.33	67.33 0.33	79.67 0.58	80 0.58	83.33 0.33	81.33 0.33	87.33 0.33	90 1	90 0.58
S 8 **S.E (±)**	85.67 0.33	66.67 0.33	65.67 0.33	66.67 0.33	68.33 0.33	78.33 0.33	78.33 0.33	83 0.58	82 0.58	83.33 0.33	88.33 0.58	89 0.58

2. Temperature (^{0}C)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1 **S.E (±)**	26 0.58	26.67 0.33	26.33 0.33	24.33 0.03	23.33 0.33	18.7 0.33	16.33 0.33	16.33 0.33	17.33 0.33	21.33 0.33	24.67 0.58	26.67 0.33
S 2 **S.E (±)**	28.67 0.33	29.67 0.33	29.33 0.33	26.67 0.03	27.33 0.33	23.7 0.33	21.67 0.33	19 0.58	18.67 0.33	22.33 0.33	27.33 0.58	27.33 0.33
S 3 **S.E (±)**	29.67 0.33	30.67 0.33	30.67 0.33	27.33 0.33	27.67 0.33	24.3 0.33	23 0.33	20.33 0.33	20.33 0.33	23 0.58	29.33 0.58	29.33 0.33
S 4 **S.E (±)**	29.33 0.33	31.33 0.33	30.67 0.33	27.67 0.03	28.33 0.33	23.3 0.33	22.67 0.33	21.33 0.33	20.67 0.33	22.67 0.33	29 1	28.33 0.33
S 5 **S.E (±)**	29.67 0.33	30.33 0.33	29.67 0.33	28.67 0.03	27.33 0.33	24.7 0.33	23.33 0.33	20.67 0.33	21 0.58	26.33 0.33	27.67 0.58	28.67 0.33
S 6 **S.E (±)**	26.33 0.33	25.33 0.33	26.67 0.33	25.67 0.03	25 0.58	23.3 0.33	22.33 0.33	19.67 0.33	20 0.58	22.33 0.33	23.67 0.58	24 0.57
S 7 **S.E (±)**	26.67 0.33	25.67 0.33	25.33 0.33	27 0.58	25.33 0.33	24.3 0.33	23.67 0.33	21.67 0.33	22 0.58	23.67 0.33	23.33 0.58	26.33 0.33
S 8 **S.E (±)**	25.67 0.33	24.67 0.33	25.67 0.33	26.33 0.03	23.67 0.33	23.7 0.33	22 0.58	20 0.58	21.33 0.33	21.67 0.33	24.67 0.58	24.33 0.33

3. Electrical conductivity (µS/cm)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	167.03	167.2	177.27	173.43	187.13	198.73	232.2	240.9	254.1	305.53	256.67	269.67
S.E (±)	0.29	0.21	0.15	0.18	0.26	0.27	0.36	0.72	0.32	0.33	0.33	0.88
S 2	151.77	146.53	156.37	138.8	138.87	138.4	147.4	158.17	163.2	179.67	213.5	220.67
S.E (±)	0.32	0.18	0.23	0.21	0.26	0.17	0.29	0.35	0.61	0.3	0.29	0.38
S 3	182.8	143.63	145.1	140.5	131.83	143.83	142.3	157.9	158.13	159.7	190.27	198
S.E (±)	0.21	0.15	0.21	0.21	0.26	0.12	0.23	0.32	0.3	0.21	0.7	0.59
S 4	179.73	125.7	136.87	133.83	125.87	134.53	141.43	159.07	156.37	161.37	189.73	196.17
S.E (±)	0.27	0.23	0.2	0.18	0.15	0.23	0.24	0.29	0.55	0.18	0.75	0.23
S 5	176.73	120.9	130.17	109.3	118.7	138.93	139.6	160.43	155.87	157.57	181.17	190.67
S.E (±)	0.35	0.21	0.29	0.23	0.23	0.49	0.29	0.24	0.41	0.15	0.44	0.38
S 6	181.7	148.43	137.4	147.5	142.63	154	158.7	162.9	161.17	160.73	184.27	184.9
S.E (±)	0.26	0.18	0.21	0.23	0.15	0.38	0.23	0.29	0.48	0.54	0.4	0.23
S 7	179.87	147.7	139.77	149.2	141.73	152.17	151.7	158.77	157.5	157.73	192.07	186.43
S.E (±)	0.58	0.12	0.18	0.21	0.15	0.29	0.26	0.41	0.21	0.12	0.71	0.24
S 8	179.17	147.07	141.83	144.57	141.33	153.27	150.77	157.23	156.97	158.27	190.6	188.7
S.E (±)	0.41	0.18	0.38	0.15	0.15	0.29	0.24	0.29	0.18	0.12	0.7	0.4

4. Nitrate (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	0.96	0.74	0.49	0.66	0.62	0.99	0.93	0.8	0.48	1.2	0.74	0.81
S.E (±)	0.02	0.02	0.03	0.03	0.02	0.01	0.02	0.01	0.01	0.03	0.03	0.01
S 2	1.18	0.87	0.42	0.44	0.36	0.63	1.13	1.03	0.72	0.47	0.5	0.73
S.E (±)	0.02	0.01	0.04	0.02	0.02	0.01	0.02	0.03	0.02	0.03	0.01	0.01
S 3	0.84	0.66	0.29	0.55	0.43	0.52	1.04	0.82	0.78	0.43	0.48	0.66
S.E (±)	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.01	0.01	0.01	0.01
S 4	0.65	0.61	0.29	0.41	0.29	0.48	1.02	0.72	0.75	0.4	0.52	0.57
S.E (±)	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01
S 5	0.87	0.69	0.46	0.38	0.32	0.52	0.84	0.85	0.97	0.48	0.54	0.65
S.E (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.03	0.01
S 6	1.18	0.92	0.78	0.42	0.37	0.92	0.94	0.6	1.08	0.53	0.48	0.79
S.E (±)	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
S 7	0.73	0.81	0.42	0.44	0.31	0.76	1.17	0.8	0.76	0.5	0.51	0.73
S.E (±)	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
S 8	0.78	0.6	0.45	0.45	0.4	0.73	0.87	0.74	0.79	0.48	0.49	0.7
S.E (±)	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.03	0.02	0.01	0.01	0.01

5. Sulphate (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1 **S.E (±)**	18.26 0.07	16.75 0.04	15.72 0.02	13.38 0.05	19.63 0.1	14.46 0.12	16.65 0.02	21.44 0.04	21.56 0.02	25.31 0.13	20.41 0.23	19.23 0.02
S 2 **S.E (±)**	16.13 0.05	14.91 0.03	14.54 0.02	8.53 0.11	10.92 0.05	9.51 0.1	10.07 0.04	14.58 0.08	19.17 0.11	12.19 0.07	18.42 0.17	17.98 0.03
S 3 **S.E (±)**	15.56 0.07	14.13 0.02	13.94 0.02	8.04 0.04	10.24 0.04	9.37 0.02	9.9 0.03	14.05 0.07	18.37 0.03	11.3 0.01	16.48 0.16	17.78 0.04
S 4 **S.E (±)**	16.06 0.06	13.42 0.02	13.77 0.02	7.95 0.07	9.73 0.03	9.37 0.02	10.03 0.04	13.88 0.05	18.04 0.03	11.23 0.07	16.29 0.05	17.07 0.02
S 5 **S.E (±)**	15.14 0.04	13.36 0.02	13.52 0.02	7.66 0.03	9.84 0.03	9.68 0.02	9.69 0.04	13.68 0.07	18.38 0.04	10.92 0.05	15.54 0.03	17.39 0.03
S 6 **S.E (±)**	20.39 0.04	18.83 0.01	16.81 0.01	11.72 0.04	12.86 0.02	11.12 0.03	10.59 0.02	13.59 0.09	18.65 0.03	11.39 0.02	15.7 0.06	18.36 0.02
S 7 **S.E (±)**	20.43 0.04	18.12 0.03	16.47 0.02	9.96 0.03	12.77 0.07	10.96 0.05	10.28 0.07	13.43 0.09	18.38 0.04	10.95 0.1	16.08 0.02	18.67 0.03
S 8 **S.E (±)**	17.58 0.05	19 0.02	16.91 0.02	10.12 0.08	12.61 0.02	10.72 0.05	10.15 0.03	13.69 0.04	17.87 0.03	10.86 0.04	16.15 0.03	16.91 0.04

6. Chloride (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1 **S.E (±)**	17.63 0.43	12.31 0.47	19.41 0.47	20.35 0.47	24.14 1.42	26.98 0.82	21.77 0.47	17.99 0.47	16.57 0.47	28.4 0.82	20.35 0.47	33.13 1.25
S 2 **S.E (±)**	16.09 0.47	11.83 0.47	22.72 0.82	19.41 0.95	22.25 0.47	19.88 0.82	19.41 0.47	12.78 0.82	17.51 0.47	23.67 0.47	17.05 0.83	21.3 0.82
S 3 **S.E (±)**	12.78 0.82	10.41 0.47	19.41 0.47	21.3 0.82	20.83 0.47	20.83 0.47	18.46 0.82	13.73 0.47	18.46 0.82	19.8 0.82	18.46 0.82	17.99 0.47
S 4 **S.E (±)**	11.83 0.47	8.99 0.47	19.88 0.82	17.51 0.95	19.88 0.82	23.67 0.47	19.88 0.82	13.25 0.47	19.88 0.82	21.77 0.47	17.04 0.82	18.93 0.47
S 5 **S.E (±)**	17.51 0.95	10.89 0.47	20.35 0.95	18.46 0.82	19.41 0.95	22.25 0.47	19.41 0.47	13.73 0.47	16.57 0.95	20.83 0.47	16.57 0.47	18.93 0.95
S 6 **S.E (±)**	16.57 0.47	9.47 0.47	16.57 0.47	20.35 0.47	21.77 0.95	22.72 0.82	20.35 0.95	14.2 0.82	14.67 0.47	18.93 0.47	17.04 0.95	18.46 0.82
S 7 **S.E (±)**	13.25 1.25	11.83 0.47	17.51 0.47	22.25 0.47	25.09 0.95	19.88 0.82	24.14 0.82	14.67 0.47	16.09 0.47	17.99 0.47	15.15 0.47	17.51 0.47
S 8 **S.E (±)**	13.73 0.47	13.73 0.47	16.09 0.47	24.61 0.47	22.25 0.47	25.56 0.82	23.19 0.47	16.09 0.47	15.15 0.47	17.51 0.47	17.99 0.47	20.35 0.47

7. Total alkalinity (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	91.67	98.33	91.67	121.67	91.67	146.67	161.67	126.67	143.33	146.67	131.67	143.33
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
S 2	78.33	76.67	83.33	76.67	76.67	96.67	96.67	86.67	93.33	101.67	108.33	138.33
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
S 3	96.67	68.33	78.33	66.67	81.67	93.33	103.33	93.33	98.67	96.67	103.33	131.67
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
S 4	98.33	71.67	91.67	73.33	71.67	96.67	98.33	81.67	96.67	96.67	108.33	128.33
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
S 5	96.67	66.67	88.33	66.67	58.33	101.67	93.33	98.33	91.67	91.67	106.67	126.67
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
S 6	86.67	76.67	71.67	76.67	71.67	96.67	108.33	88.33	93.33	93.33	116.67	126.67
S.E (±)	1.67	1.67	1.67	1.67	2.89	1.67	1.67	1.67	1.67	1.67	1.67	1.67
S 7	93.33	83.33	66.67	81.67	73.33	103.33	106.67	86.67	95	88.33	103.33	131.67
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	0	1.67	1.67	1.67
S 8	88.33	81.67	76.67	86.67	76.67	111.67	113.33	91.67	96.67	91.67	106.67	126.67
S.E (±)	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67

8. Total hardness (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	80	76	89.33	58.67	77.33	86.67	98	128	113.33	130	100.67	101.33
S.E (±)	1.15	1.15	0.67	0.67	0.67	0.67	1.15	1.15	0.67	1.15	0.67	0.67
S 2	70.67	69.33	84.67	64.67	66	61.33	64.67	72.67	82	83.33	85.33	94.67
S.E (±)	0.67	1.15	0.67	0.67	1.15	0.67	0.67	0.67	1.15	0.67	0.67	0.67
S 3	90.67	54	81.33	58.67	64.67	59.33	65.33	71.33	73.33	76.67	76	90
S.E (±)	1.33	1.15	0.67	0.67	0.67	0.67	0.67	1.33	1.33	1.33	1.15	1.15
S 4	84.67	55.33	80	61.33	62.67	63.33	59.33	68.67	69.33	76	80	85.33
S.E (±)	0.67	0.67	1.15	O.67	1.15	0.67	0.67	0.67	0.67	1.15	1.15	0.67
S 5	83.33	54.67	79.33	51.33	62	60.67	60	72.67	73.33	79.33	74	80
S.E (±)	0.67	0.67	0.67	0.67	1.15	0.67	1.15	0.67	0.67	0.67	1.15	1.15
S 6	81.33	64.67	85.33	43.33	67.33	64	68.67	74.67	72	73.33	76.67	86
S.E (±)	0.67	0.67	0.67	0.67	0.67	1.15	0.67	0.67	1.15	0.67	0.67	1.15
S 7	86.67	69.33	82.67	78.67	64.67	66	66.67	73.33	75.33	71.67	72.67	80
S.E (±)	0.67	0.67	0.67	0.67	0.67	1.15	0.67	0.67	0.67	0.67	0.67	1.15
S 8	84	73.33	76	67.33	68.67	67.33	69.33	72.67	68.67	72.67	76	87.33
S.E (±)	1.15	0.67	1.15	0.67	0.67	0.67	0.67	0.67	0.67	0.67	1.15	0.67

9. Calcium (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	14.7	16.83	18.71	14.16	14.43	22.44	21.91	31.03	22.17	26.18	21.64	22.43
S.E (±)	0.53	0.46	0.27	0.27	0.46	0.46	0.53	0.28	0.27	0.27	0.46	0.46
S 2	13.1	11.75	13.36	12.56	12.56	15.5	13.36	13.1	13.9	14.96	20.57	19.24
S.E (±)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.46
S 3	16.67	11.49	11.75	10.15	11.22	14.96	13.1	12.83	14.16	14.76	17.1	17.9
S.E (±)	0.33	0.71	0.27	0.27	0.8	0.27	0.27	0.46	0.27	0.33	0.27	0.96
S 4	15.5	9.89	9.62	9.35	10.69	13.36	11.75	13.9	13.63	13.1	18.17	17.37
S.E (±)	0.53	0.27	0.46	0.27	0.53	0.27	0.27	0.53	0.46	0.27	0.27	0.54
S 5	15.76	10.15	9.35	9.35	9.89	14.16	12.56	13.36	13.9	15.23	17.64	16.03
S.E (±)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.53	0.53	0.46	0.46	0.46
S 6	14.7	15.23	11.49	11.49	13.63	13.9	14.16	12.29	13.36	15.5	16.83	15.76
S.E (±)	0.27	0.46	0.27	0.27	0.46	0.53	0.27	0.27	0.27	0.27	0.46	0.53
S 7	16.3	13.63	12.56	12.56	12.56	15.23	13.9	12.83	13.9	13.9	17.9	16.3
S.E (±)	0.27	0.46	0.27	0.27	0.27	0.46	0.53	0.46	0.27	0.27	0.54	0.27
S 8	15.23	14.7	11.75	11.75	13.1	16.3	13.36	13.9	13.63	14.96	17.37	17.64
S.E (±)	0.46	0.27	0.27	0.27	0.27	0.53	0.27	0.27	0	0.27	0.27	0.46

10. Magnesium (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	10.55	8.18	10.39	5.52	10.14	7.31	10.55	12.5	14.13	15.59	11.53	10.88
S.E (±)	0.16	0.1	0.33	0.16	0.36	0	0.16	0.16	0.01	0.28	0.17	0.32
S 2	9.09	9.91	12.67	8.28	8.28	5.52	7.63	9.75	11.37	11.21	8.12	11.36
S.E (±)	0.16	0.16	0.16	0.28	0.28	0.16	0.16	0.01	0.16	0.01	0.16	0.16
S 3	11.85	6.17	12.5	8.12	8.93	5.36	7.96	9.42	9.26	9.74	7.96	11.04
S.E (±)	0.16	0.16	0.16	0.16	0.43	0	0.16	0.16	0.28	0.28	0.16	0.33
S 4	11.2	6.88	13.15	9.09	8.93	6.82	7.31	8.6	8.44	10.55	8.61	10.55
S.E (±)	0.28	0.55	0.28	0.16	0.16	0.49	0.28	0.16	0.16	0.16	0.17	0.16
S 5	10.71	7.15	13.48	6.98	9.09	5.85	6.82	9.74	9.42	10.39	7.47	9.9
S.E (±)	0.28	0.16	0.16	0.16	0.16	0.28	0.28	0.28	0.17	0.32	0.16	0.16
S 6	11.04	6.49	13.31	4.06	8.12	7.15	8.12	10.71	9.26	8.44	8.44	11.63
S.E (±)	0.16	0.16	0.33	0.65	0.16	0.16	0.16	0.01	0.28	0.16	0.16	0.23
S 7	11.37	8.44	12.34	11.37	7.79	6.82	7.96	10.39	9.91	9.26	6.98	9.74
S.E (±)	0.16	0.16	0.16	0.17	0.28	0.28	0.16	0.16	0.16	0.28	0.33	0.28
S 8	11.2	8.93	11.37	9.09	8.61	6.49	8.92	9.42	8.6	8.61	7.8	10.55
S.E (±)	0.01	0.16	0.16	0.16	0.16	0.16	0.15	0.32	0.59	0.16	0.49	0.16

11. Dissolved Oxygen (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1 **S.E (±)**	9.06 0.12	8.86 0.12	9.87 0.12	9.53 0.29	8.39 0.07	9.39 0.18	9.87 0.12	11.07 0.12	12.01 0.18	11.14 0.07	9.87 0.21	8.53 0.13
S 2 **S.E (±)**	8.39 0.18	9.73 0.18	8.86 0.12	12.15 0.07	9.19 0.13	7.52 0.07	7.98 0.07	10.47 0.12	10 0.67	10.14 0.18	12.89 0.21	7.18 0.24
S 3 **S.E (±)**	11.14 0.14	6.24 0.12	8.12 0.27	12.01 0.24	8.86 0.12	7.72 0.07	7.65 0.12	10.94 0.07	9.73 0.07	10.07 0.12	11.55 0.12	8.99 0.18
S 4 **S.E (±)**	10.4 0.18	10.34 0.07	9.8 0.14	11.88 0.12	9.6 0.14	7.38 0.07	7.72 0.07	9.87 0.12	9.8 0.07	10.54 0.07	10.6 0.12	9.87 0.12
S 5 **S.E (±)**	10.87 0.12	8.59 0.07	8.93 0.13	12.08 0.2	8.53 0.13	7.18 0.07	7.99 0.18	9.33 0.07	9.94 0.07	10.2 0.07	10.67 0.2	9.26 0.12
S 6 **S.E (±)**	4.83 0.12	7.65 0.12	8.39 0.13	10.54 0.07	6.98 0.18	7.25 0.12	9.73 0.07	13 0.12	11.07 0.12	11.14 0.07	11.07 0.21	12.01 0.18
S 7 **S.E (±)**	5.44 0.12	7.25 0.12	8.12 0.07	10.2 0.18	7.52 0.07	8.05 0.12	9.87 0.12	12.15 0.07	10.8 0.07	10.94 0.07	10.8 0.12	11.41 0.18
S 8 **S.E (±)**	6.11 0.18	7.85 0.12	7.78 0.07	10.81 0.29	7.12 0.18	7.92 0.07	10.14 0.07	12.41 0.18	11 0.07	11.34 0.14	11.28 0.21	11.88 0.12

12. Biological Oxygen Demand (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1 **S.E (±)**	1.88 0.07	1.14 0.07	1.88 0.07	1.74 0.07	1.14 0.07	2.89 0.13	2.89 0.07	2.68 0.07	2.75 0.07	1.14 0.07	1.95 0.07	1.81 0
S 2 **S.E (±)**	3.83 0.12	3.36 0.07	2.69 0.07	3.09 0.13	3.15 0.07	2.69 0.07	2.82 0.12	3.42 0.12	2.09 0.07	1.41 0.12	6.51 0.07	1.81 0.12
S 3 **S.E (±)**	3.49 0.07	3.1 0.03	2.09 0.07	2.69 0.18	2.55 0.07	1.14 0.07	1.34 0.07	3.69 0.07	1.54 0.07	1.08 0.07	4.7 0.07	0.94 0.07
S 4 **S.E (±)**	3.89 0.07	3.69 0.07	2.95 0.07	2.82 0.12	1.75 0.07	1.28 0.07	1.54 0.07	2.29 0.07	1.18 0.09	1.14 0.07	1.94 0.18	1.27 0.07
S 5 **S.E (±)**	2.68 0.07	2.75 0.07	2.15 0.24	2.95 0.13	1.61 0.12	1.54 0.07	1.82 0.12	2.14 0.07	1.95 0.07	0.88 0.07	1.74 0.13	1 0
S 6 **S.E (±)**	1.24 0.15	0.53 0.07	1.61 0.1	1.48 0.07	2.55 0.07	0.88 0.07	2.68 0.07	4.56 0.07	1.01 0.01	0.47 0.07	1.08 0.24	0.94 0.07
S 7 **S.E (±)**	1.28 0.07	0.61 0	1.88 0.07	1.34 0.07	2.34 0.07	1.07 0.07	1.75 0.07	3.62 0.12	2.21 0.12	1.14 0.07	1.07 0.07	0.74 0.07
S 8 **S.E (±)**	1.48 0.07	0.67 0.07	1.78 0.15	0.94 0.18	2.22 0.12	1 0.01	2.21 0.11	4.02 0.12	1.88 0.07	1.27 0.07	1.48 0.07	1.67 0.06

13. Free Carbondioxide (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	7.36	6.6	10.63	10.27	5.5	9.17	7.7	6.6	4.77	6.6	9.17	9.17
S.E (±)	0.38	0.64	0.37	0.73	0.64	0.37	0.64	0.64	0.37	0.64	0.64	0.37
S 2	6.6	6.97	5.87	8.43	6.97	8.07	9.53	6.23	6.23	6.23	4.77	10.27
S.E (±)	0.64	0.37	0.73	2.04	0.73	0.37	0.73	0.73	0.37	0.37	0.64	0.37
S 3	4.77	8.8	7.7	8.8	6.23	9.53	8.43	4.03	5.5	6.97	5.13	6.23
S.E (±)	0.37	0.64	0.64	0.64	0.37	0.37	0.73	0.37	0.64	0.37	0.37	0.37
S 4	7.33	8.07	6.23	6.67	5.13	9.17	8.07	6.23	5.13	7.33	5.87	5.87
S.E (±)	0.73	0.37	0.73	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.64	0.37
S 5	8.43	7.33	7.7	5.87	6.23	8.07	6.97	5.5	6.23	8.07	4.77	5.87
S.E (±)	0.37	0.73	0.64	0.73	0.37	0.37	0.37	0.64	0.37	0.37	0.64	0.37
S 6	7.33	6.97	9.17	8.07	8.07	9.53	6.6	5.13	5.87	7.33	7.33	8.07
S.E (±)	0.37	0.37	0.37	0.97	0.37	0.37	0.64	0.37	0.37	0.37	0.64	0.37
S 7	9.17	7.7	9.9	6.97	7.7	10.63	6.23	4.77	5.13	6.6	6.97	6.97
S.E (±)	0.97	0.64	0.64	0.37	0.64	0.37	0.37	0.37	0.37	0.64	0.64	0.37
S 8	8.07	8.43	9.53	5.5	7.33	10.27	5.13	4.4	6.23	5.87	7.33	5.87
S.E (±)	0.37	0.37	0.73	0.64	0.37	0.37	0.73	0.64	0.37	0.37	0.64	0.37

14. *p*H

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	7.9	7.97	7.93	7.17	7.03	7.13	7.3	7.08	7.14	8.73	8.53	8.13
S.E (±)	0.06	0.09	0.07	0.07	0.07	0.03	0.1	0.13	0.08	0.07	0.15	0.12
S 2	7.03	7.63	8.6	8.07	7.6	6.83	7.13	6.93	7.12	7.97	8.77	7.9
S.E (±)	0.09	0.07	0.06	0.15	0.06	0.03	0.09	0.03	0.05	0.09	0.15	0.06
S 3	8.7	7.13	8.43	8.17	7.33	6.77	6.6	6.77	6.87	8.13	8.83	8.7
S.E (±)	0.06	0.03	0.03	0.03	0.09	0.03	0.06	0.03	0.05	0.07	0.12	0.06
S 4	8.67	8.33	8.6	7.57	7.47	6.73	6.63	6.6	6.86	8.2	8.6	8.73
S.E (±)	0.03	0.03	0.06	0.23	0.03	0.03	0.07	0.06	0.05	0.06	0.1	0.03
S 5	8.9	7.87	8.2	7.9	7.57	6.93	6.5	6.4	6.85	8.33	8.4	8.93
S.E (±)	0.06	0.07	0.12	0.06	0.03	0.03	0.06	0.12	0.06	0.03	0.1	0.09
S 6	7.83	7.37	7.63	7.4	6.43	6.67	7.03	6.87	6.75	8.57	8.07	8.8
S.E (±)	0.07	0.03	0.09	0.06	0.03	0.03	0.09	0.03	0.05	0.03	0.15	0.06
S 7	7.57	7.23	7.37	7.47	6.53	6.87	7.47	7.07	6.99	8.43	7.67	8.97
S.E (±)	0.03	0.03	0.03	0.07	0.03	0.03	0.09	0.03	0.05	0.03	0.15	0.03
S 8	7.63	7.63	7.47	7.53	6.67	6.9	7.2	6.8	6.89	8.47	8.13	8.67
S.E (±)	0.03	0.03	0.07	0.03	0.03	0.06	0.06	0.06	0.05	0.03	0.15	0.09

15. Phosphate phosphorus (PO_4-P) (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	0.41	0.47	0.68	0.28	0.44	0.25	0.27	0.21	0.18	0.2	0.23	0.35
S.E (±)	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01
S 2	0.36	0.26	0.38	0.24	0.26	0.2	0.25	0.22	0.2	0.18	0.21	0.25
S.E (±)	0.01	0.01	0.01	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0	0.01
S 3	0.25	0.24	0.37	0.23	0.24	0.21	0.22	0.26	0.23	0.2	0.21	0.23
S.E (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
S 4	0.23	0.23	0.31	0.21	0.25	0.21	0.21	0.21	0.22	0.21	0.24	0.25
S.E (±)	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0	0.01	0.01
S 5	0.26	0.3	0.36	0.23	0.28	0.23	0.24	0.24	0.25	0.2	0.22	0.29
S.E (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
S 6	0.47	0.51	0.53	0.35	0.4	0.28	0.26	0.2	0.22	0.19	0.25	0.37
S.E (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0	0.01
S 7	0.43	0.48	0.51	0.33	0.39	0.28	0.25	0.19	0.24	0.22	0.51	0.41
S.E (±)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
S 8	0.33	0.49	0.56	0.37	0.44	0.29	0.27	0.19	0.28	0.19	0.49	0.38
S.E (±)	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01

16. Potassium (mg/L)

Sites	Jun. 2016	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 2107	Feb.	Mar.	Apr.	May
S 1	21.52	9.79	11.39	10.32	9.34	4.91	2.48	1.79	2.32	9.02	7.58	20.84
S.E (±)	0.41	0.65	0.08	0.08	0.08	0.13	0.08	0.08	0.08	0.12	0.2	0.2
S 2	13.52	9.41	12.15	9.18	8.42	4.31	1.11	2.71	4.38	5.98	9.41	8.42
S.E (±)	0.02	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
S 3	9.87	10.32	13.22	10.25	8.88	5.52	1.86	4.31	4.99	5.75	7.89	6.86
S.E (±)	0.2	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.13	0.07
S 4	10.63	7.58	10.09	9.56	8.65	6.59	1.64	3.39	4.38	5.6	7.81	6.59
S.E (±)	0.13	0.2	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.13	0.08	0.08
S 5	10.32	10.41	12.15	11.54	10.02	5.91	3.01	4.61	5.22	6.21	7.28	7.2
S.E (±)	0.15	0.13	0.08	0.13	0.08	0.08	0.08	0.08	0.08	0.08	0.2	0.13
S 6	18.32	17.41	18.25	13.29	11.01	6.89	3.92	5.06	4.52	6.36	7.51	6.29
S.E (±)	0.2	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.07	0.2	0.13
S 7	20.38	17.11	17.6	12.61	9.71	4.84	3.16	4.15	4.76	6.66	8.11	7.05
S.E (±)	0.33	0.08	0.11	0.08	0.13	0.07	0.07	0.08	0.07	0.08	0.13	0.08
S 8	16.88	18.55	18.71	14.06	8.04	4.99	3.69	4.46	6.65	6.36	9.18	6.82
S.E (±)	0.2	0.08	0.08	0.13	0.07	0.08	0.08	0.13	1.63	0.15	0.08	0.08

Appendix-II

Seasonal variations of sixteen physicochemical parameters of water samples from eight selected sampling station along Doyang River.

1. TDS (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	134.42	0.67	80.09	0.47	111.50	0.70
S 2	97.92	0.80	69.00	0.42	74.67	0.52
S 3	89.25	0.82	70.42	0.33	72.00	0.39
S 4	86.75	0.56	67.00	0.68	71.50	0.33
S 5	86.42	0.59	64.00	0.46	70.84	0.33
S 6	84.00	0.46	70.31	0.47	78.25	0.48
S 7	87.17	0.56	70.83	0.53	77.58	0.46
S 8	85.67	0.52	71.17	0.33	77.00	0.39

2. TEMPERATURE (^{0}C)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	22.50	0.39	25.83	0.32	18.67	0.33
S 2	23.92	0.39	28.59	0.26	22.93	0.39
S 3	25.50	0.46	29.59	0.33	23.83	0.33
S 4	25.17	0.50	29.75	0.26	23.91	0.33
S 5	25.92	0.46	29.59	0.26	24.01	0.33
S 6	22.50	0.52	26.00	0.26	22.58	0.39
S 7	23.83	0.46	26.17	0.39	23.74	0.33
S 8	23.00	0.39	25.59	0.26	22.34	0.46

3. CONDUCTIVITY (µS/cm)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	271.49	0.47	171.23	0.21	214.74	0.40
S 2	194.26	0.40	148.37	0.24	145.71	0.27
S 3	176.53	0.45	153.01	0.20	143.97	0.23
S 4	175.91	0.43	144.03	0.22	140.23	0.23
S 5	171.32	0.35	134.28	0.27	139.42	0.31
S 6	172.77	0.41	153.76	0.22	154.56	0.26
S 7	173.43	0.32	154.14	0.27	151.09	0.28
S 8	173.64	0.35	153.16	0.28	150.65	0.24

4. NITRATE (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	0.81	0.02	0.71	0.03	0.84	0.02
S 2	0.61	0.02	0.73	0.02	0.79	0.02
S 3	0.59	0.01	0.59	0.02	0.70	0.02
S 4	0.56	0.01	0.49	0.02	0.63	0.02
S 5	0.66	0.02	0.60	0.01	0.63	0.02
S 6	0.72	0.01	0.83	0.02	0.71	0.01
S 7	0.63	0.01	0.60	0.02	0.76	0.01
S 8	0.62	0.01	0.57	0.02	0.69	0.02

5. SULPHATE (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	21.63	0.10	16.03	0.05	18.05	0.07
S 2	16.94	0.10	13.53	0.05	11.27	0.07
S 3	15.98	0.06	12.92	0.04	10.89	0.04
S 4	15.66	0.04	12.80	0.04	10.75	0.04
S 5	15.56	0.04	12.42	0.03	10.72	0.04
S 6	16.03	0.03	16.94	0.03	12.04	0.04
S 7	16.02	0.05	16.25	0.03	11.86	0.07
S 8	15.45	0.04	15.90	0.04	11.79	0.04

6. CHLORIDE (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	24.61	0.75	17.43	0.46	22.72	0.80
S 2	19.88	0.65	17.51	0.68	18.58	0.65
S 3	18.68	0.73	15.98	0.65	18.46	0.56
S 4	19.41	0.65	14.55	0.68	19.17	0.65
S 5	18.23	0.71	16.80	0.80	18.70	0.59
S 6	17.28	0.68	15.74	0.47	19.76	0.89
S 7	16.69	0.47	16.21	0.67	20.95	0.77
S 8	17.75	0.47	17.04	0.47	21.77	0.56

7. ALKALINITY (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	141.25	1.67	100.84	1.67	131.67	1.67
S 2	110.42	1.67	78.75	1.67	89.17	1.67
S 3	107.59	1.67	77.50	1.67	92.92	1.67
S 4	107.50	1.67	83.75	1.67	87.09	1.67
S 5	104.17	1.67	79.59	1.67	87.92	1.67
S 6	107.50	1.67	77.92	1.67	91.25	1.98
S 7	104.58	1.25	81.25	1.67	92.50	1.67
S 8	105.42	1.67	83.34	1.67	98.34	1.67

8. HARDNESS (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	111.33	0.79	76.00	0.91	97.50	0.91
S 2	86.33	0.79	72.34	0.79	66.17	0.79
S 3	79.00	1.24	71.17	0.96	65.17	0.84
S 4	77.67	0.91	70.33	0.83	63.50	0.79
S 5	76.67	0.91	67.17	0.67	63.84	0.91
S 6	77.00	0.91	68.67	0.67	68.67	0.79
S 7	74.92	0.79	79.34	0.67	67.67	0.79
S 8	76.17	0.79	75.17	0.91	69.50	0.67

9. CALCIUM (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	23.11	0.37	16.10	0.38	22.45	0.43
S 2	17.17	0.32	12.69	0.27	13.63	0.27
S 3	15.98	0.46	12.52	0.40	13.03	0.45
S 4	15.57	0.39	11.09	0.38	12.43	0.40
S 5	15.70	0.48	11.15	0.27	12.49	0.34
S 6	15.36	0.38	13.23	0.32	13.50	0.38
S 7	15.50	0.34	13.76	0.32	13.63	0.43
S 8	15.90	0.25	13.36	0.32	14.17	0.34

10. MAGNESIUM (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	13.03	0.20	8.66	0.19	10.13	0.17
S 2	10.52	0.12	9.99	0.19	7.80	0.15
S 3	9.50	0.26	9.66	0.16	7.92	0.19
S 4	9.54	0.16	10.08	0.32	7.92	0.27
S 5	9.30	0.20	9.58	0.19	7.88	0.25
S 6	9.44	0.21	8.73	0.33	8.53	0.12
S 7	8.97	0.26	10.88	0.16	8.24	0.22
S 8	8.89	0.35	10.15	0.12	8.36	0.20

11. DO (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	10.39	0.15	9.33	0.16	9.68	0.12
S 2	10.05	0.33	9.78	0.14	8.79	0.10
S 3	10.09	0.12	9.38	0.19	8.79	0.10
S 4	10.20	0.10	10.61	0.13	8.64	0.10
S 5	10.02	0.12	10.12	0.13	8.26	0.11
S 6	11.32	0.15	7.85	0.11	9.24	0.12
S 7	10.99	0.11	7.75	0.12	9.40	0.10
S 8	11.38	0.14	8.14	0.17	9.40	0.13

12. BOD (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	1.91	0.05	1.66	0.07	2.40	0.09
S 2	2.96	0.10	3.24	0.10	3.02	0.10
S 3	2.07	0.07	2.84	0.09	2.18	0.07
S 4	1.38	0.10	3.34	0.08	1.72	0.07
S 5	1.39	0.07	2.63	0.13	1.78	0.10
S 6	0.88	0.10	1.22	0.10	2.67	0.07
S 7	1.29	0.08	1.28	0.05	2.20	0.08
S 8	1.58	0.07	1.22	0.12	2.36	0.09

13. CO_2 (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	7.43	0.51	8.72	0.53	7.24	0.57
S 2	6.88	0.44	6.97	0.95	7.70	0.64
S 3	5.96	0.44	7.52	0.57	7.06	0.46
S 4	6.05	0.44	7.08	0.55	7.15	0.37
S 5	6.24	0.44	7.33	0.62	6.69	0.44
S 6	7.15	0.44	7.89	0.52	7.33	0.44
S 7	6.42	0.51	8.44	0.66	7.33	0.44
S 8	6.33	0.44	7.88	0.53	6.78	0.53

14. p^H

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	8.21	0.12	7.74	0.07	7.14	0.08
S 2	7.86	0.09	7.83	0.09	7.12	0.05
S 3	8.10	0.07	8.11	0.04	6.87	0.05
S 4	8.08	0.06	8.29	0.09	6.86	0.05
S 5	8.13	0.06	8.22	0.08	6.85	0.06
S 6	8.17	0.07	7.56	0.06	6.75	0.05
S 7	8.06	0.06	7.41	0.04	6.99	0.05
S 8	8.14	0.08	7.57	0.04	6.89	0.05

15. PHOSPHORUS (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	0.24	0.01	0.46	0.01	0.29	0.24
S 2	0.21	0.01	0.31	0.02	0.23	0.21
S 3	0.22	0.01	0.27	0.01	0.23	0.22
S 4	0.23	0.01	0.25	0.01	0.22	0.23
S 5	0.24	0.01	0.29	0.01	0.25	0.24
S 6	0.26	0.01	0.47	0.01	0.29	0.26
S 7	0.35	0.01	0.44	0.01	0.28	0.35
S 8	0.34	0.01	0.44	0.01	0.30	0.34

16. POTASSIUM (mg/L)

SITES	PRE MONSOON	S.E (±)	MONSOON	S.E (±)	POSTMONSOON	S.E (±)
S 1	9.94	0.15	13.26	0.31	4.63	0.09
S 2	7.05	0.08	11.07	0.07	4.14	0.08
S 3	6.37	0.09	10.92	0.11	5.14	0.08
S 4	6.10	0.09	9.47	0.12	5.07	0.08
S 5	6.48	0.12	11.11	0.12	5.89	0.08
S 6	6.17	0.12	16.82	0.11	6.72	0.08
S 7	6.65	0.09	16.93	0.15	5.47	0.09
S 8	7.25	0.49	17.05	0.12	5.30	0.09

Appendix-III

Seasonal Variation of WQI from the eight selected sampling stations

Sampling station	Pre monsoon		Monsoon		Post monsoon	
	WQI	WQS	WQI	WQS	WQI	WQS
S 1	49.99	Good	38.74	Good	40.21	Good
S 2	54.90	Poor	51.81	Poor	39.68	Good
S 3	55.29	Poor	49.82	Good	31.56	Good
S 4	51.89	Poor	48.52	Good	29.68	Good
S 5	50.11	Poor	47.26	Good	31.92	Good
S 6	43.52	Good	37.06	Good	32.69	Good
S 7	42.57	Good	37.09	Good	34.62	Good
S 8	44.54	Good	38.02	Good	33.47	Good

Average seasonal WQI of Doyang River

Seasons	WQI	WQS
Pre monsoon	49.10	Good
Monsoon	43.54	Good
Post monsoon	34.23	Good

Appendix-IV

Seasonal values of soil physico-chemical parameters from seven selected land use activities along Doyang River

1. Soil texture

Sites	Composition (%)	Pre-monsoon	Monsoon	Post-monsoon
S 1	Clay	20.65	21.90	24.55
	Silt	28.38	46.40	36.25
	sand	50.98	31.70	39.20
S 2	Clay	42.95	39.80	38.75
	Silt	34.00	46.10	41.20
	sand	23.05	14.10	20.05
S 3	Clay	34.35	30.20	30.30
	Silt	42.45	45.00	42.48
	sand	23.20	24.80	27.23
S 4	Clay	28.03	23.60	29.08
	Silt	32.18	43.10	34.50
	sand	39.80	33.30	36.43
S 5	Clay	27.45	20.30	27.48
	Silt	38.13	26.70	32.95
	sand	34.43	53.00	39.33
S 6	Clay	27.58	18.80	21.95
	Silt	37.40	33.50	34.73
	sand	35.03	47.70	43.08
S 7	Clay	36.70	22.40	25.95
	Silt	34.58	38.50	33.65
	sand	28.73	39.10	40.40

2. Bulk density (g/cm^3)

Sites	Soil depth(cm)	Pre-monsoon	Monsoon	Post-monsoon
S 1	0-10	0.93	1.01	1.05
	10-20	1.11	0.92	1.02
	20-30	1.14	1.13	1.05
S 2	0-10	0.81	1.09	0.85
	10-20	1.06	1.06	0.86
	20-30	1.15	1.16	0.99
S 3	0-10	0.99	0.95	0.91
	10-20	0.91	0.93	0.98
	20-30	1.04	0.99	1.01
S 4	0-10	0.97	1.00	0.91
	10-20	1.06	1.02	0.84
	20-30	1.06	0.97	0.95
S 5	0-10	1.01	1.07	1.05
	10-20	1.13	1.07	1.05
	20-30	1.13	1.09	1.11
S 6	0-10	0.94	1.07	1.11
	10-20	1.00	1.10	1.04
	20-30	0.92	0.85	1.03
S 7	0-10	0.81	0.82	0.89
	10-20	0.77	0.74	0.87
	20-30	1.01	0.89	0.90

3. Soil porosity (%)

Sites	Soil depth(cm)	Pre-monsoon	Monsoon	Post-monsoon
S 1	0-10	50.81	43.29	41.49
	10-20	44.48	46.68	44.53
	20-30	39.91	35.32	44.54
S 2	0-10	61.62	39.08	51.90
	10-20	51.87	42.21	54.09
	20-30	45.58	32.10	48.61
S 3	0-10	43.35	44.40	48.41
	10-20	48.43	47.27	47.57
	20-30	44.19	43.87	47.10
S 4	0-10	56.47	42.49	50.23
	10-20	49.50	41.68	54.06
	20-30	52.35	43.95	48.60
S 5	0-10	49.46	41.45	44.52
	10-20	43.73	40.46	44.50
	20-30	44.30	39.58	41.17
S 6	0-10	54.16	38.74	40.49
	10-20	53.52	37.61	44.02
	20-30	57.79	51.22	43.86
S 7	0-10	56.96	51.08	52.64
	10-20	56.23	57.79	52.15
	20-30	47.17	49.18	53.04

4. Soil temperature (^oC)

Sites	Pre-monsoon	Monsoon	Post-monsoon
S 1	21.03	26.07	19.03
S 2	22.13	26.83	20.80
S 3	30.45	31.18	26.28
S 4	24.03	28.38	21.58
S 5	24.53	30.30	20.28
S 6	22.90	30.13	23.75
S 7	21.40	27.98	20.65

5. Soil moisture (%)

Sites	Pre-monsoon	Monsoon	Post-monsoon
S 1	80.65	79.21	79.18
S 2	84.22	80.63	83.11
S 3	83.18	81.86	83.59
S 4	84.70	82.81	84.33
S 5	80.35	80.07	78.30
S 6	82.35	78.94	79.83
S 7	84.81	77.14	79.23

6. Soil organic carbon (%)

Sites	Pre-monsoon	Monsoon	Post-monsoon
S 1	0.97	1.61	1.45
S 2	1.75	1.86	2.00
S 3	1.61	1.59	1.89
S 4	1.38	1.68	1.60
S 5	1.20	1.10	1.00
S 6	0.77	1.18	0.86
S 7	1.71	1.60	1.40

7. Soil *p*H

Sites	Pre-monsoon	Monsoon	Post-monsoon
S 1	6.25	6.62	6.46
S 2	6.65	6.61	6.35
S 3	6.49	6.50	6.18
S 4	5.84	5.80	5.74
S 5	6.16	6.31	6.36
S 6	6.38	6.21	6.33
S 7	5.39	5.77	5.52

Appendix- V: Phytosociological data of herb, shrub and tree found along Doyang river.

1. Herbs Layer

Sl. No.	Species	Family	Relative dominance	Relative density	Relative frequency	IVI
1.	*Arundo donax* L.	Poaceae	3.63	8.11	2.83	14.57
2.	*Flosco pascandens* Lour.	Commelinaceae	0.30	6.44	4.72	11.46
3.	*Rorippa indica* (L.) Hiern	Brassicaceae	0.16	6.03	2.83	9.01
4.	*Zingiber rubens* Roxb.	Zingiberaceae	2.41	3.74	6.60	12.76
5.	*Ageratum conyzoides* (L.) L.	Asteraceae	0.23	8.94	5.66	14.83
6.	*Amischoto lypehookeri* (Hassk.) H.Hara	Commelinaceae	1.74	7.48	8.49	17.71
7.	*Remusatia vivipara* (Roxb.) Schott	Araceae	1.25	3.95	3.77	8.97
8.	*Crassocephalum crepidioides* (Benth.) S.Moore	Asteraceae	0.34	7.48	4.72	12.54
9.	*Crinum amoenum* Ker Gawl. exRoxb.	Amaryllidaceae	1.34	3.53	12.26	17.14
10.	*Elatostema monandrum* (Buch.-Ham. ex D.Don) H.Hara	Urticaceae	0.13	11.23	5.66	17.02
11.	*Wallichia oblongifolia* Griff.	Arecaceae	86.01	3.12	10.38	99.51
12.	*Phrynium pubinerve* Blume	Marantaceae	0.55	7.69	11.32	19.56
13.	*Cheilocostus speciosus* (J.Koenig) C.D.Specht	Costaceae	0.97	4.16	6.60	11.73
14.	*Commelina benghalensis* L.	Commelinaceae	0.15	8.32	7.55	16.01
15.	*Thysanola enalatifolia* (Roxb. ex Hornem.) Honda	Poaceae	0.73	7.07	1.89	9.68
16.	*Pseuderanthemum crenulatum* (Wall. ex Lindl.) Radlk.	Acanthaceae	0.07	2.70	4.72	7.49
Total			100.00	100.00	100.00	300.00

2. Shrub Layer

Sl. No.	Species	Family	Relative dominance	Relative density	Relative frequency	IVI
1.	*Lee aalata* Edgew.	Vitaceae	2.42	4.23	4.65	11.29
2.	*Mycetia longifolia* (Wall.) Kuntze	Rubiaceae	1.79	5.92	6.20	13.91
3.	*Breynia retusa* (Dennst.) Alston	Phyllanthaceae	2.88	4.23	3.88	10.98
4.	*Capparisa cutifolia* Sweet	Capparaceae	1.70	7.32	11.63	20.65
5.	*Chloranthus elatior* Link	Chloranthaceae	2.15	9.30	9.30	20.75
6.	*Ficuss quamosa* Roxb.	Moraceae	5.99	5.63	3.88	15.50
7.	*Clerodendrum robustum* Klotzsch	Lamiaceae	8.22	3.94	5.43	17.59
8.	*Clerodendrum infortunatum* L.	Lamiaceae	9.06	4.79	6.98	20.82
9.	*Gnetum acutum* Markgr.	Gnetaceae	1.96	6.48	10.85	19.29
10.	*Chromola enaodorata* (L.) R.M.King&H.Rob.	Asteraceae	3.02	7.89	4.65	15.56
11.	*Mussaenda roxburghii* Hook.f.	Rubiaceae	9.40	4.51	5.43	19.33
12.	*Piper lonchites*	Piperaceae	9.59	5.07	5.43	20.09
13.	*Premna pinguis* C.B.Clarke	Lamiaceae	12.52	8.17	4.65	25.34
14.	*Maesa indica* (Roxb.) A. DC.	Primulaceae	2.39	7.89	8.53	18.80
15.	*Flemingia strobilifera* (L.) W.T.Aiton	Fabaceae	9.06	5.92	3.88	18.86
16.	*Ixora acuminate* Roxb.	Rubiaceae	3.75	3.10	2.33	9.18
17.	*Homonoia riparia* Lour.	Euphorbiaceae	14.09	5.63	2.33	22.05
Total			100.00	100.00	100.00	300.00

3. Trees Layer

Sl. No.	Species	Family	R. Dom	R.D	R.F	IVI
1.	*Ficus auriculata* Lour.	Moraceae	6.51	4.35	5.72	16.58
2.	*Syzygium formosum* (Wall.) Masam.	Myrtaceae	7.65	11.96	13.73	33.34
3.	*Albizia chinensis* (Osbeck) Merr.	Leguminosae	1.37	1.09	1.83	4.29
4.	*Stereospermum chelonoides* (L. f.) DC.	*Bignoniaceae*	2.68	3.26	2.75	8.69
5.	*Magnolia hodgsonii* (Hook. f. & Thomson) H. Keng	Magnoliaceae	6.08	7.97	7.32	21.38
6.	*Alangium chinense* (Lour.) Harms	Cornaceae	2.74	6.16	4.58	13.48
7.	*Bischofia javanica* Blume	Phyllanthaceae	5.51	6.52	5.49	17.52
8.	*Chukrasia tabularis* A. Juss.	Meliaceae	10.83	3.99	2.75	17.56
9.	*Grewia abutilifolia* Vent. exJuss.	Malvaceae	0.57	5.43	3.66	9.67
10.	*Callicar paarborea* Roxb.	Lamiaceae	4.26	7.25	10.07	21.58
11.	*Sterculia coccinea* Jack.	Sterculiaceae	0.80	1.81	1.83	4.44
12.	*Triadica cochinchinensis* Lour.	Euphorbiaceae	13.82	6.16	5.49	25.47
13.	*Duabanga grandiflora* (DC.) Walp.	Lythraceae	5.88	3.62	3.66	13.16
14.	*Sumbavio psisalbicans* (Blume) J.J.Sm.	Euphorbiaceae	12.07	13.41	15.56	41.04
15.	*Trevesia palmata* (Roxb. ex Lindl.) Vis.	Araliaceae	5.16	8.70	6.41	20.26
16.	*Melia azedarach* L.	Meliaceae	5.50	3.26	2.75	11.51
17.	*Terminalia myriocarpa* Van Heurck&Müll. Arg.	Combretaceae	6.29	2.90	4.58	13.76
18.	*Pterospermum acerifolium* (L.) Willd.	Malvaceae	2.26	2.17	1.83	6.27
Total			100.00	100.00	100.00	300.00

Appendix VI: Diversity Indices of herb, shrub and tree of found along the Doyang riparian zone

Diversity Indices	Herb	Shrub	Tree
Species richness (S)	16	17	18
Shannon-Weiner's diversity index (H′)	2.697	2.792	2.723
Simpsons' diversity index (D)	0.858	0.94	0.93
1-D	0.142	0.06	0.07
Simpsons' reciprocal index (1/D)	1.165	1.064	1.075
Hill's diversity number (N1)	14.83	16.31	15.22
Hill's diversity number (N2)	1.165	1.064	1.075
Richness index (R)	2.428	2.895	3.20
Evenness Index (E)	0.973	0.985	0.942
Menhinick's index (D)	0.73	0.90	1.08