

06. RESULTS

The periodic real time survey data of the current investigation at Doyang reservoir, Nagaland with respect to the different physic-chemical parameters of water, abundance and diversity of fish resources during February, 2015 to January, 2018 are presented in this section. The study was performed at regular mode of interval with the support of scientific expertise and local fisherman. All the output (data) result is validated in standard international protocols. All analysis was performed in two respective time segment on monthly basis; 1st phase (February, 2015 to May, 2016) and 2nd phase (June, 2016 to January, 2018). Accordingly several statistical analyses which may establish a comprehensive relationship between fish diversity to the given physic-chemicals parameters at the respective study sites also figure out.

Recorded fish species from the study area

From the study area, total 64 numbers of fish species were physically documented during the whole research period at Doyang reservoir, Nagaland. All recorded finfishes are formulated by local name, IUCN status and their population trends in present scenario (Table 3). It has been found from the collected data that, there are total 16 families under 6 orders among which Cyprinidae family shares the highest number (39) and common to the rest followed by Siluridae, Sisoridae, Mastacembelidae, Heteropneustidae, Channidae, Belonidae, Nemacheilidae etc. (Figure 18). Among the 6 orders Cypriniformes showed the highest number of species (45) followed by Perciformes, Siluriformes, Synbranchiformes, Beloniformes, Anguilliformes etc. (Table 4, Figure 19). Subsequently, present investigation also support that, most of the available fish species belongs from Least Concern (LC) whereas 08 numbers of fish species under NT (Near Threatened), 05 are under VU (Vulnerable), 01 is under EN (Endangered), 02 species are NE (Not Evaluated) and 03 species belongs to DD (Data Deficient) categories as directed by IUCN Red list (Ver. 2019-1) (Table 5, Figure 20). Documented fishes are indigenous, some numbers are endemic and few shows heterogeneous distribution, variations also depend on season-wise rainfall and temperature fluctuations. Based on the research output, 27 fish species was found to be of Ornamental value, while 24 numbers of fish species seems to be of commercial value and the remaining 21 species are showing minor commercial value.

Table no 3: Checklist of Fin-fishes available at Doyang Reservoir, Nagaland.

Sl. No	Order	Family	Scientific name	Local name	Human Uses	IUCN (2019-1)	Population trends
1	Anguilliformes	Anguillidae	<i>Anguilla bengalensis</i> (Gray, 1831)	Ngesu	Minor commercial	NT	Unknown
2	Beloniformes	Belonidae	<i>Xenentodon cancila</i> (Hamilton, 1822)	Jukli	Aquarium	LC	Unknown
3	Cypriniformes	Botiidae	<i>Botia dario</i> (Hamilton, 1822)	Ngotsuko serao	Aquarium; commercial	LC	Unknown
4		Cobitidae	<i>Lepidocephalichthys berdmorei</i> (Blyth, 1860)	Rhitong	Non commercial	LC	Unknown
5		Cyprinidae	<i>Bangana dero</i> (Hamilton, 1822)	Napenchok	Commercial	LC	Unknown
6			<i>Barilius barila</i> (Hamilton, 1822)	Lilum Serao	Aquarium	LC	Unknown
7			<i>Barilius bendelisis</i> (Hamilton, 1807)	Lilum Tsurio	Aquarium	LC	Stable
8			<i>Barilius vagra</i> (Hamilton, 1822)	Lilum	Non commercial	LC	Unknown
9			<i>Chagunius chagunio</i> (Hamilton, 1822)	Nungruk Menchio	Commercial	LC	Unknown
10			<i>Chagunius nicholsi</i> (Myers, 1924)	Ngeli	Non commercial	LC	Unknown
11			<i>Cirrhinus mrigala</i> (Hamilton, 1822)	Mirka	Commercial	LC	Stable
12			<i>Crossocheilus burmanicus</i> (Hora, 1936)	Dongtsu	Aquarium	LC	Unknown
13			<i>Crossocheilus latius</i> (Hamilton, 1822)	Dongtsu	Minor commercial; aquarium	LC	Unknown
14			<i>Ctenopharyngodon idella</i> (Valenciennes, 1844)	Kras carp	Highly commercial	NE	Unknown
15			<i>Cyprinion semiplotum</i> (McClelland, 1839)	Chunki	Minor commercial	VU	Decreasing
16			<i>Cyprinus carpio</i> (Linnaeus, 1758)	Common carp	Highly commercial	VU	Unknown
17			<i>Danio dangila</i> (Hamilton, 1822)	Ngolelup	Aquarium	LC	Decreasing
18			<i>Devario aequipinnatus</i> (McClelland, 1839)	Nguluplup	Commercial	LC	Unknown
19			<i>Devario devario</i> (Hamilton, 1822)	Ngolelup	Minor commercial; aquarium	LC	Unknown

20			<i>Devario naganensis</i> (Chaudhuri, 1912)	Tsirongo	Minor commercial	VU	Decreasing
21			<i>Esomus danrica</i> (Hamilton, 1822)	Ngatuko	Commercial	LC	Stable
22			<i>Garra annandalei</i> (Hora, 1921)	Engoro	Aquarium	LC	Unknown
23			<i>Garra gotyla</i> (Gray, 1830)	Ngarum	Minor commercial	LC	Unknown
24			<i>Garra lissorhynchus</i> (McClelland, 1842)	Engoro	Aquarium	LC	Unknown
25			<i>Garra maclellandi</i> (Jerdon, 1849)	Nongoro	Minor commercial	LC	Unknown
26			<i>Garra naganensis</i> (Hora, 1921)	Engoro	Non commercial	LC	Unknown
27			<i>Gibelion catla</i> (Hamilton, 1822)	Baho/Katla	Highly commercial	LC	Unknown
28			<i>Hypophthalmichthys molitrix</i> (Valenciennes, 1844)	Silver	Highly commercial	NT	Decreasing
29			<i>Labeo bata</i> (Hamilton, 1822)	Suvo	Highly commercial	LC	Unknown
30			<i>Labeo calbasu</i> (Hamilton, 1822)	Nungruk	Highly commercial	LC	Unknown
31			<i>Labeo dyocheilus</i> (McClelland, 1839)	Naro	Highly commercial	LC	Unknown
32			<i>Labeo gonius</i> (Hamilton, 1822)	Suvoro	Highly commercial	LC	Unknown
33			<i>Labeo pangusia</i> (Hamilton, 1822)	Napenchok	Highly commercial	NT	Decreasing
34			<i>Labeo rohita</i> (Hamilton, 1822)	Rohu	Minor commercial	LC	Unknown
35			<i>Neolissochilus hexagonolepis</i> (McClelland, 1839)	Ntssi Ngo	Highly commercial	NT	Decreasing
36			<i>Opsarius barna</i> (Hamilton, 1822)	Ninum Rakio	Minor commercial and aquarium	LC	Stable
37			<i>Pethia ticto</i> (Hamilton, 1822)	Puti Ngo	Minor commercial and aquarium	LC	Unknown
38			<i>Puntius chola</i> (Hamilton, 1822)	Bugiero	Minor commercial and aquarium	LC	Unknown
39			<i>Puntius sophore</i> (Hamilton, 1822)	Puti Ngo	Minor commercial and aquarium	LC	Unknown
40			<i>Schizothorax richardsonii</i> (Gray, 1832)	Mungksio	Minor commercial and aquarium	VU	Decreasing
41			<i>Systemus sarana</i> (Hamilton, 1822)	Puti Ngo	Minor commercial	LC	Unknown
42			<i>Tor putitora</i> (Hamilton, 1822)	Ntsingoro	Minor commercial and aquarium	EN	Decreasing

43			<i>Tor tor</i> (Hamilton, 1822)	Susu	Minor commercial and aquarium	DD	Unknown
44		Nemacheilidae	<i>Schistura manipurensis</i> (Chaudhuri, 1912)	Rhitong	Highly commercial	NT	Unknown
45			<i>Schistura multifasciata</i> (Day, 1878)	Rhitong Ehumo	Aquarium	LC	Unknown
46			<i>Schistura reticulofasciata</i> (Singh & Banarescu, 1982)	Rhitong	Aquarium	VU	Unknown
47		Psilorhynchidae	<i>Psilorhynchus homaloptera</i> (Hora & Mukerji, 1935)	Tora Ngo	Aquarium	LC	Unknown
48	Perciformes	Anabantidae	<i>Anabas testudineus</i> (Bloch, 1792)	Michumro	Aquarium	DD	Unknown
49		Badidae	<i>Badis badis</i> (Hamilton, 1822)	Michumro	Highly commercial	LC	Unknown
50		Channidae	<i>Channa punctata</i> (Bloch, 1793)	Ngeyim	Minor commercial and aquarium	LC	Unknown
51			<i>Channa orientalis</i> (Bloch & Schneider, 1801)	Ngeyim	Commercial	NE	Unknown
52			<i>Channa stewartii</i> (Playfair, 1867)	Ngeyim	Minor commercial and aquarium	LC	Unknown
53			<i>Channa striata</i> (Bloch, 1793)	Ngeyim	Minor commercial and aquarium	LC	Unknown
54		Cichlidae	<i>Oreochromis mossambicus</i> (Peters, 1852)	Goai	Highly commercial	NT	Unknown
55	Siluriformes	Clariidae	<i>Clarias batrachus</i> (Linnaeus, 1758)	Magur	Highly commercial	LC	Unknown
56		Heteropneustidae	<i>Heteropneustes fossilis</i> (Bloch, 1794)	Nafusa	Highly commercial	LC	Stable
57		Siluridae	<i>Ompok bimaculatus</i> (Bloch, 1794)	Nafusa Ehumo	Highly commercial	NT	Unknown
58			<i>Ompok pabo</i> (Hamilton, 1822)	Nafusa Engutio	Highly commercial	NT	Decreasing
59			<i>Pterocryptis berdmorei</i> (Blyth, 1860)	Nafusa	Highly commercial	LC	Stable
60			<i>Pterocryptis gangelica</i> (Peters, 1861)	Nafusa	Aquarium	DD	Unknown
61		Sisoridae	<i>Glyptothorax telchitta</i> (Hamilton, 1822)	Rungsung	Aquarium	LC	Unknown
62			<i>Glyptothorax trilineatus</i> (Blyth, 1860)	Rungsung	Minor commercial	LC	Stable
63	Synbranchiformes	Mastacembelidae	<i>Macrognathus pancalus</i> (Hamilton, 1822)	Ngeru	Aquarium and commercial	LC	Unknown
64			<i>Mastacembelus armatus</i> (Lacepède, 1800)	Ngeru	Minor commercial	LC	Unknown

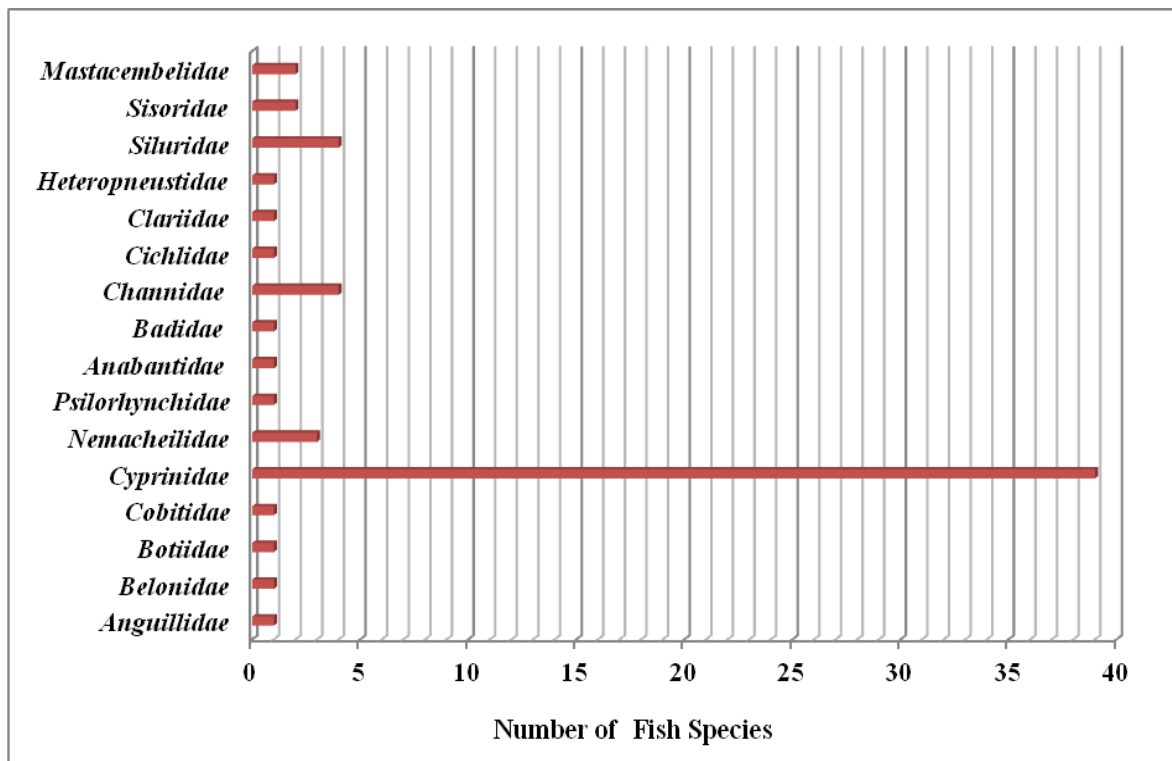


Figure 18: Bar diagram showing family wise fish availability in Doyang reservoir.

Order name	Nos.
Anguilliformes	1
Beloniformes	1
Cypriniformes	45
Perciformes	7
Siluriformes	8
Synbranchiformes	2

Table no 4: Order wise fish species number distribution in the study area.

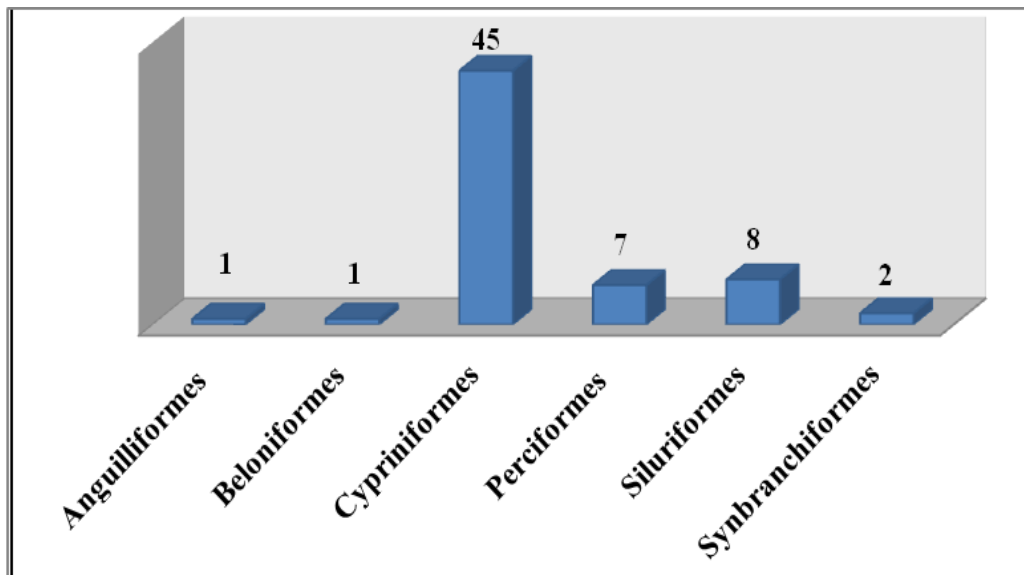


Figure 19: Diagrammatic representation of fish species in Order wise at Doyang reservoirs.

IUCN category	Number of fish species
NE	2
DD	3
LC	45
NT	8
VU	5
EN	1

Table no 5: Available fish species belongs to different IUCN (Ver. 2019-1) Red List category.

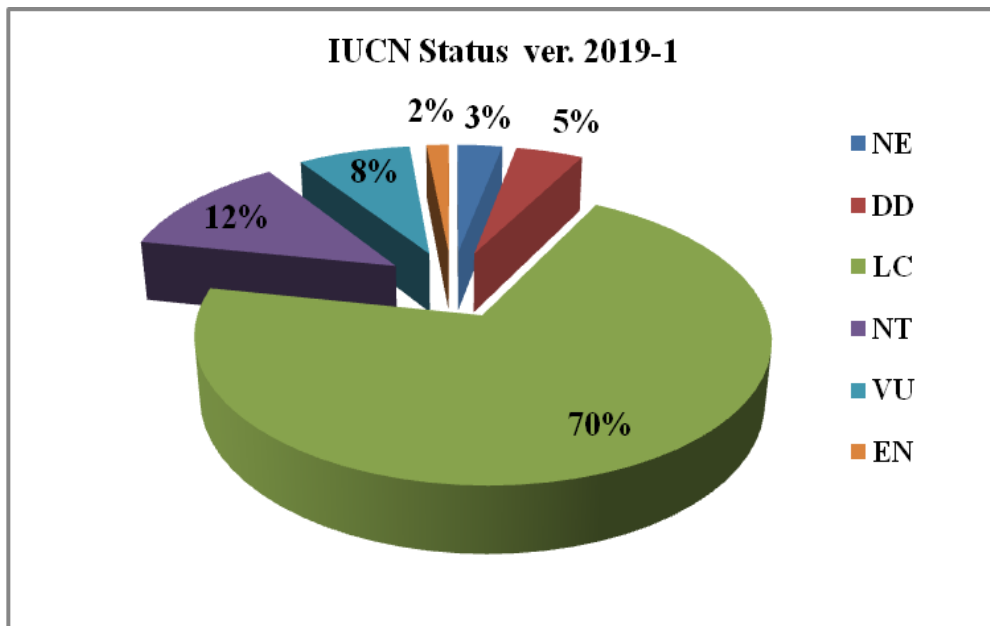


Figure 20: Pie chart shows the percentage of IUCN Red Listed species available at Doyang reservoir.

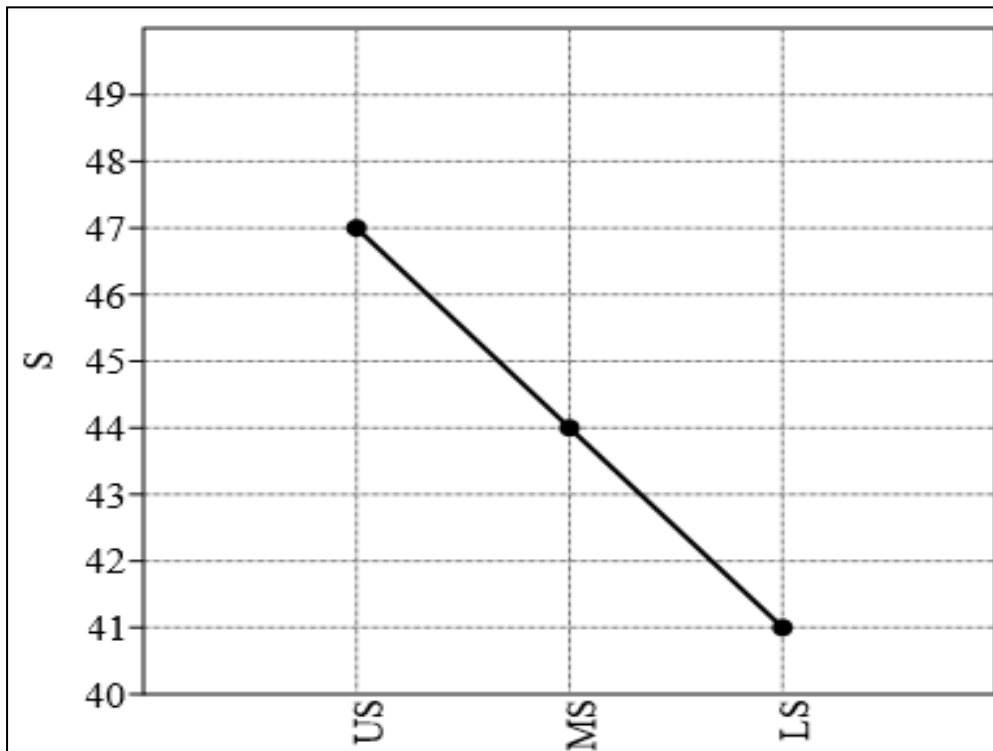


Figure 21: Diversity indices of fish species availability in different study sites of the Doyang reservoir (S- species, US-Upper Stretch, MS- Middle Stretch, LS- Lower Stretch).

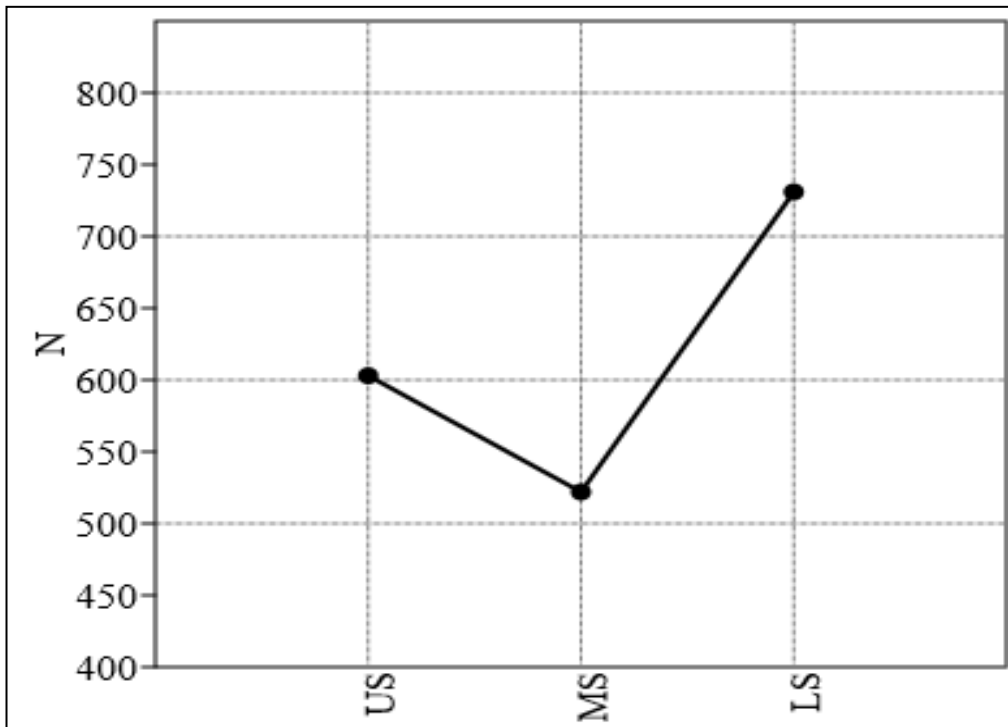


Figure 22: Number of fish species (N) sampling in different sites of Doyang reservoir.
(US-Upper Stretch, MS- Middle Stretch, LS- Lower Stretch).

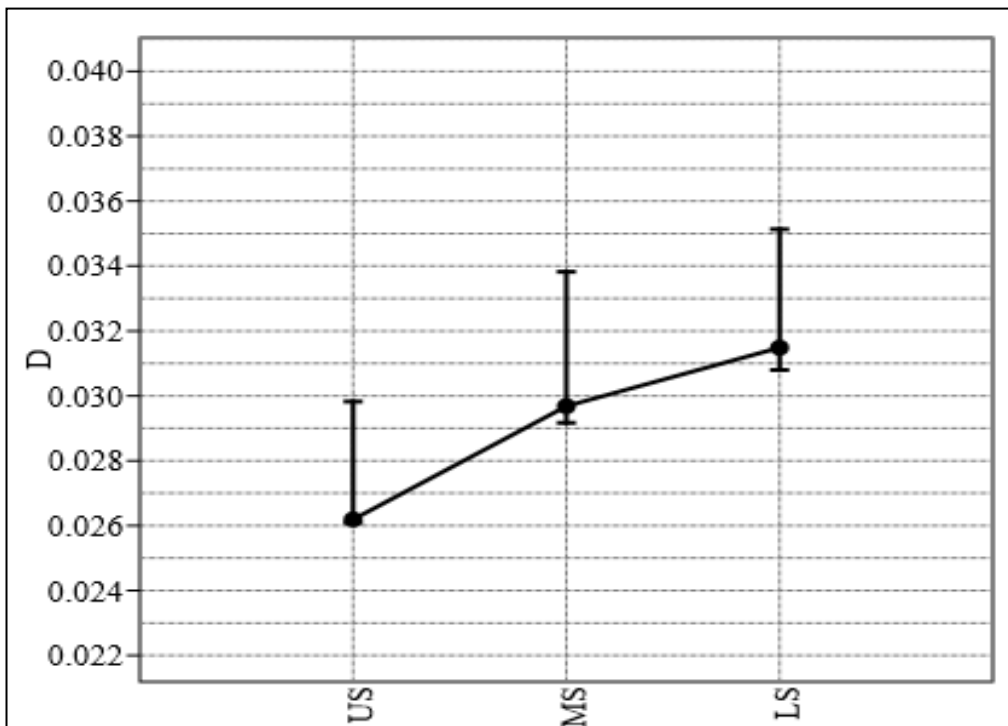


Figure 23: Species Dominance index (D) of available fish species in study sites.

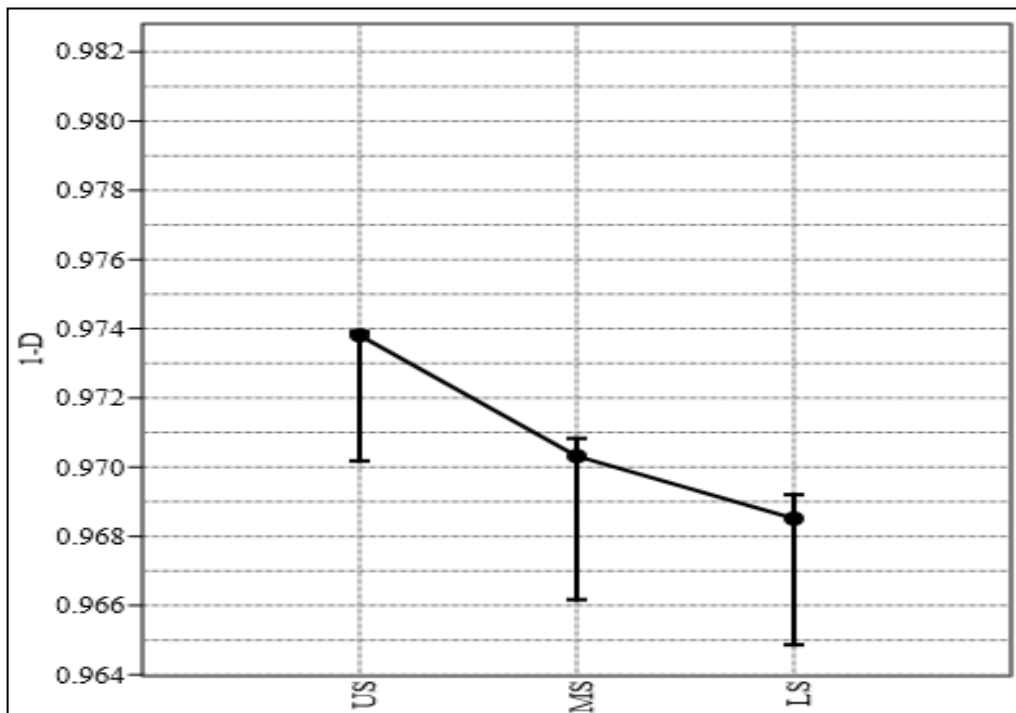


Figure 24: Simpson Dominance index (1-D) of fish species at different sites of Doyang reservoir.

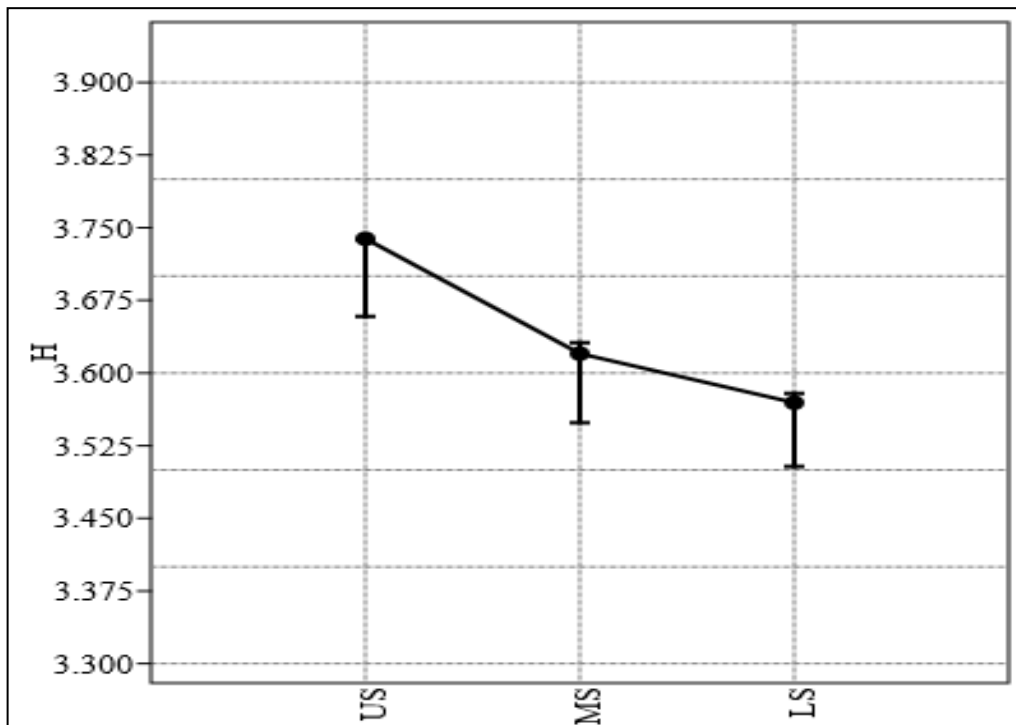


Figure 25 : Shannon Diversity indices (H) of fish fishes in respective study sites at Doyang reservoir.

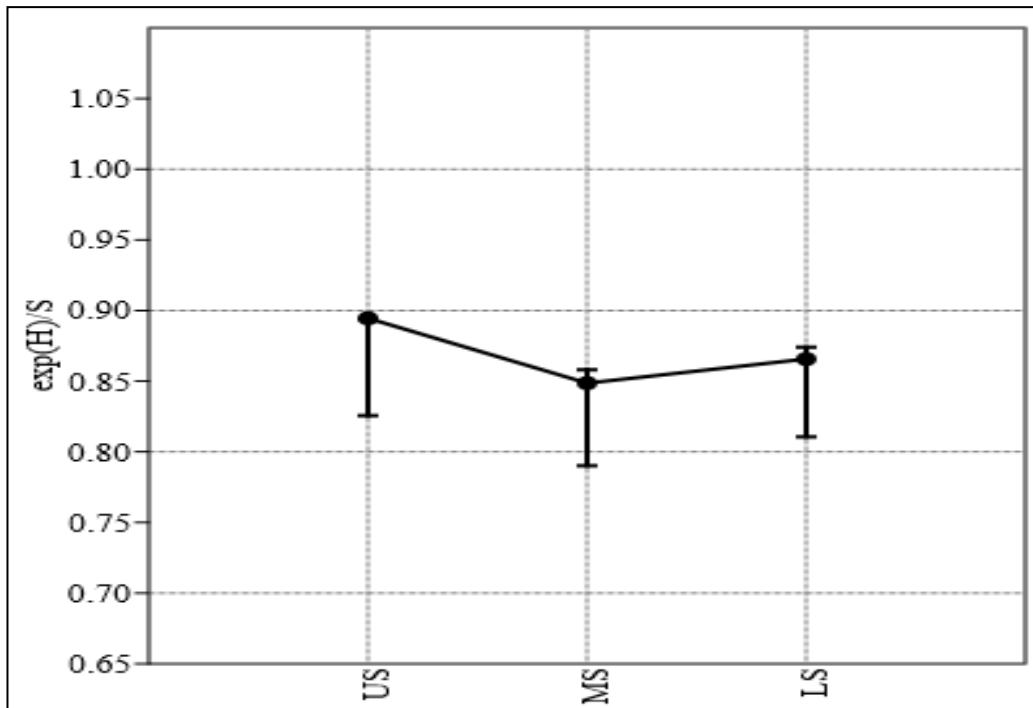


Figure 26: Evenness index (expH/s) of fish species at three different study sites at Doyang reservoir.

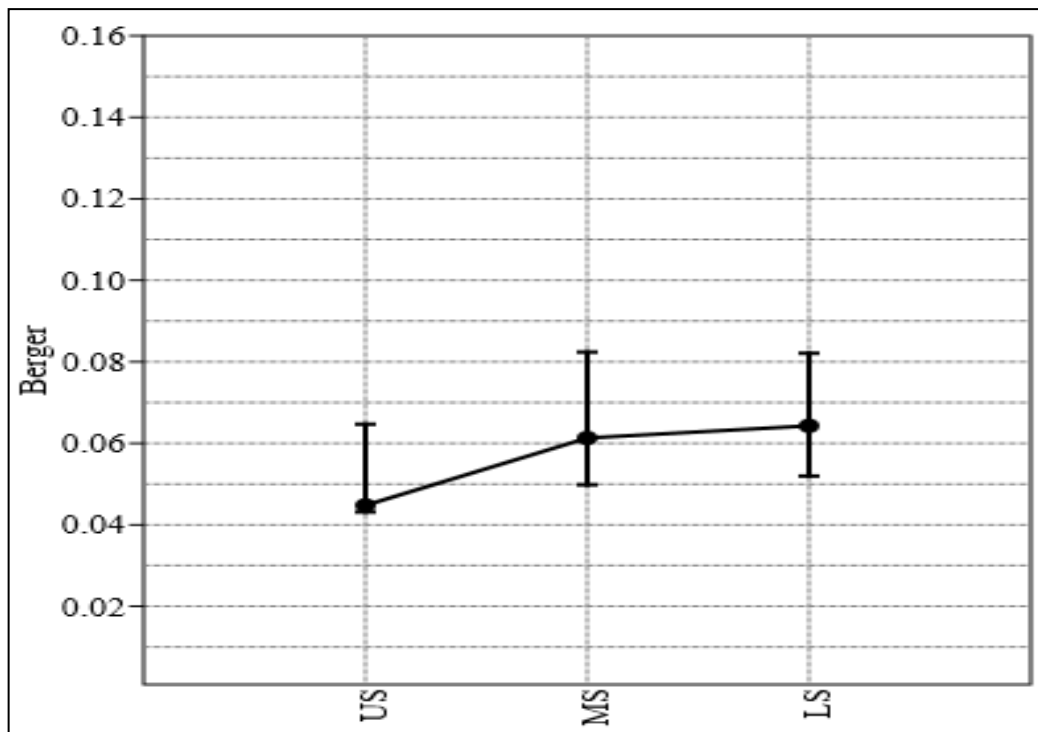


Figure 27: Berger-Parker diversity index of fish species in Doyang reservoir study area.

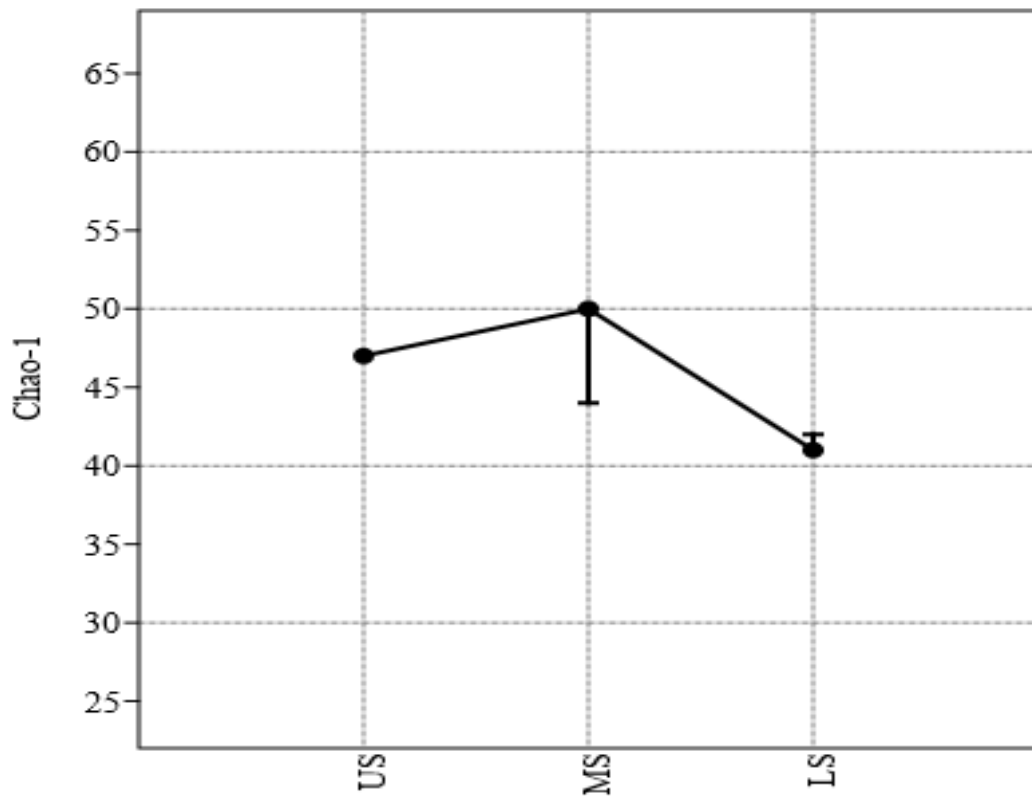


Figure 28: Chao-1 diversity indexing depending on three study areas of Doyang reservoir.

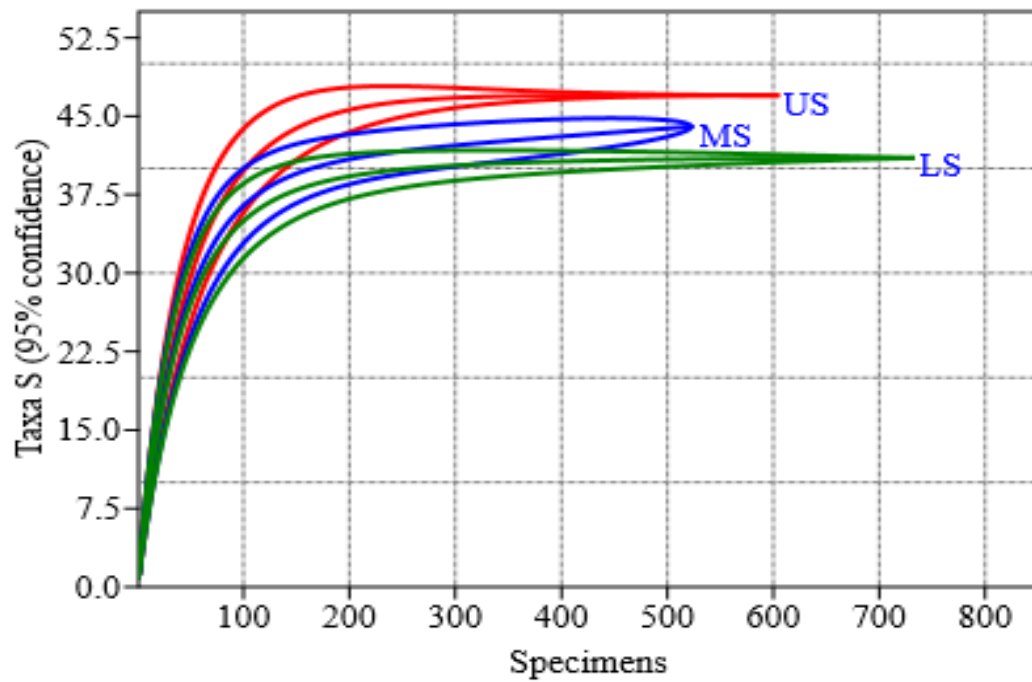


Figure 29: Individual rarefaction index between total numbers of individual (total specimen) with available fish species (Taxa.) in different study sites.

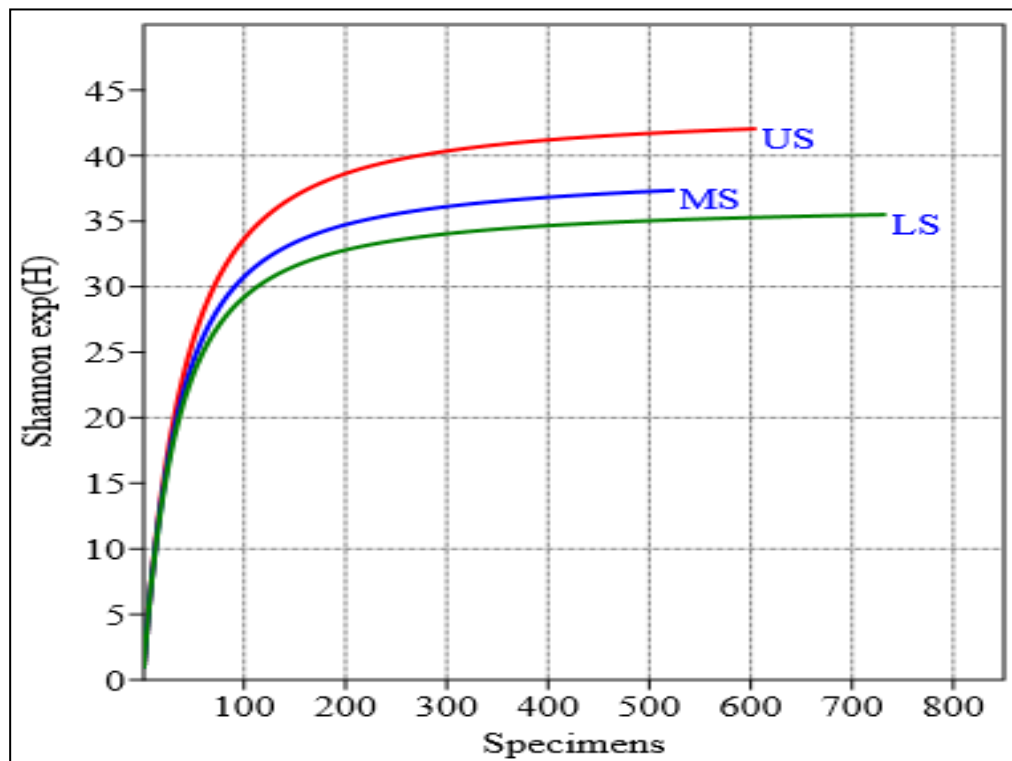


Figure 30: Individual rarefaction index between total numbers of individual (total specimen) with Shannon index (exp H) in different study sites.

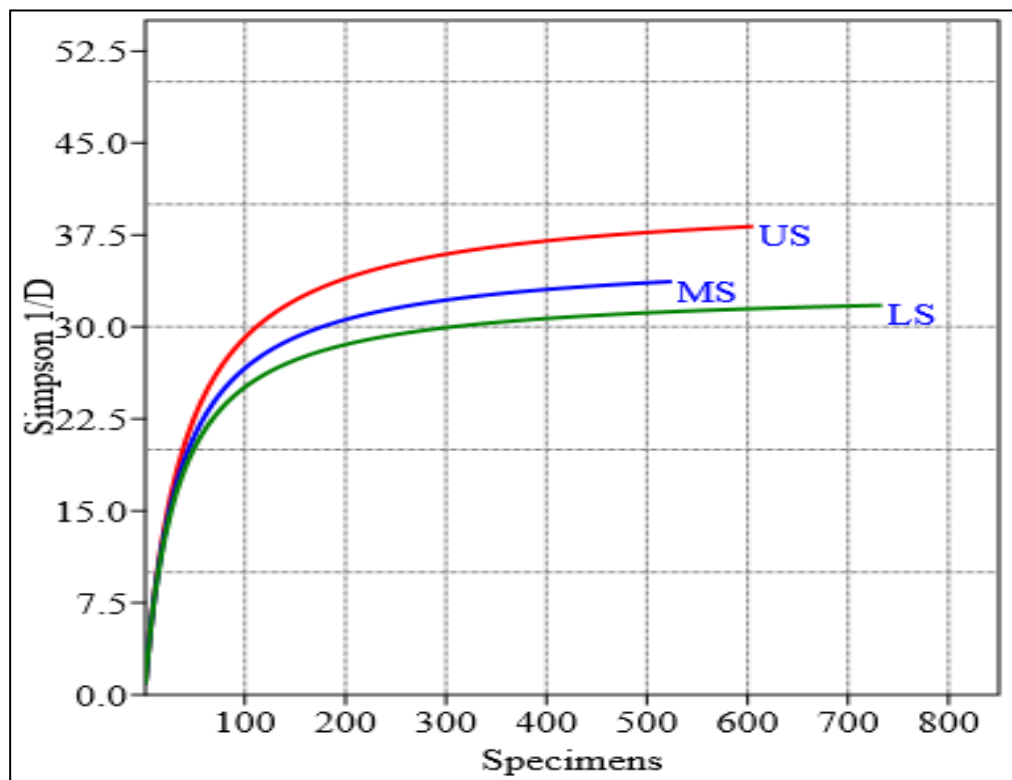


Figure 31: Individual rarefaction index between total numbers of individual (total specimen) with Simpson diversity index (1/D) in different study sites.

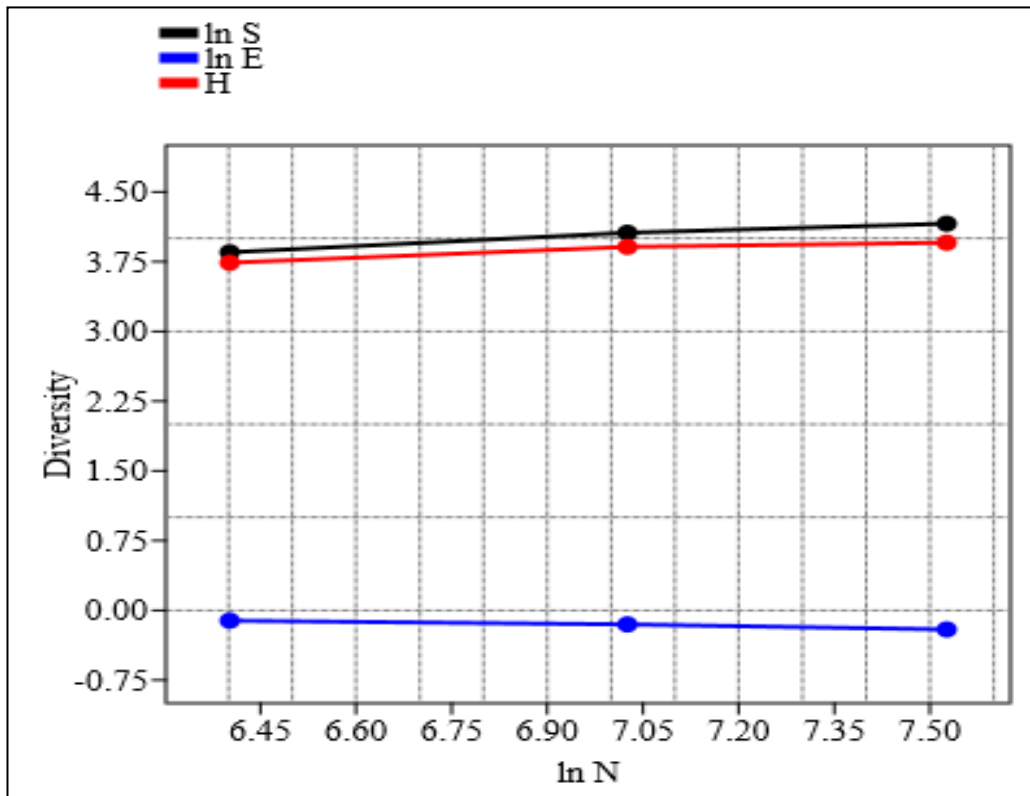


Figure 32: SHE analysis depending on three study sites through the log species abundance (ln S), Shannon index (H) and log evenness index (ln E= H-ln S) for the sample.

Months	Air Temp. (°C)	Water Temp. (°C)	Secchi depth (cm)	pH	DO (mg/l)	Free CO ₂ (mg/l)	Sp.cond. (µmhos/cm)	TDS (mg/l)	Total Alk. (mg/l)	Total hardness (mg/l)	Cl (mg/l)
Feb. 2015	16.7	17.3	145.05	7.48	6.51	0.52	140.81	92.4	46.35	61.23	12.84
Mar. 2015	16.6	16.7	141.75	7.41	6.13	0.51	140.98	92.3	46.89	60.21	12.28
Apr. 2015	23.2	23.8	143.41	7.38	6.44	0.53	142.34	93.51	45.08	61.28	11.85
May. 2015	26.9	27.6	140.87	7.3	6.72	0.32	137.72	92.55	42.62	59.33	11.56
June. 2015	30.6	29.7	136.08	7.32	6.73	0.01	136.4	93.48	39.07	58.27	12.59
July. 2015	29.7	29.5	135.16	7.38	6.44	0.03	135.02	88.21	40.66	57.21	11.11
Aug. 2015	28.4	30.4	132.41	7.37	6.72	0.28	136.82	83.5	41.2	55.98	10.39
Sep. 2015	30.5	30.1	134.79	7.4	6.73	0.52	137.81	86.21	42.3	57.63	11.26
Oct. 2015	26.1	26.3	139.37	7.46	6.82	0.43	136.92	83.7	43.61	55.28	11.35
Nov. 2015	16.2	20.6	142.83	7.48	7.13	0.46	140.26	89.26	45.01	57.11	11.64
Dec. 2015	14.9	19.3	143.75	7.49	7.25	0.54	139.73	90.21	44.03	59.99	11.89
Jan. 2016	14.1	16.7	144.47	7.41	7.31	0.57	138.81	90.1	45.67	60.27	11.58
Feb. 2016	16.8	17.4	145.97	7.47	7.52	0.56	140.83	92.4	46.31	61.24	12.23
Mar. 2016	16.6	19.1	142.29	7.44	7.31	0.53	139.99	91.3	44.83	60.41	12.11
Apr. 2016	23.1	24.2	142.02	7.39	6.88	0.59	142.33	92.19	45.39	61.47	11.6
May. 2016	26.3	28.6	140.06	7.13	6.56	0.34	137.73	92.73	41.23	60.33	11.83
June. 2016	30.1	30.2	137.28	7.33	6.19	0.04	136.49	93.48	39.74	59.67	10.09
July. 2016	30.7	30.9	136.12	7.37	6.42	0.06	138.02	86.27	38.09	58.31	11.31
Aug. 2016	28.8	30.2	133.85	7.36	6.74	0.27	139.84	87.53	39.27	55.69	11.24
Sep. 2016	30.1	30.8	136.72	7.39	6.73	0.53	140.89	89.3	41.22	56.01	11.38

Months	Air Temp. (°C)	Water Temp (°C)	Secchi depth (cm)	pH	DO (mg/l)	Free CO ₂ (mg/l)	Sp.cond. (µmhos/cm)	TDS (mg/l)	Total Alk. (mg/l)	Total hardness (mg/l)	Cl (mg/l)
Oct. 2016	27.2	28.5	138.91	7.41	6.82	0.44	139.97	90.13	42.31	56.13	12.34
Nov. 2016	16.4	20.1	140.33	7.43	6.8	0.55	137.26	90.34	44.37	56.15	12.18
Dec. 2016	14.9	19.2	144.13	7.47	7.11	0.56	136.71	92.51	45.86	58.62	12.33
Jan. 2017	13.5	17.8	144.83	7.46	7.38	0.53	139.83	91.55	44.68	59.76	11.42
Feb. 2017	16.9	17.3	145.63	7.48	7.57	0.57	137.84	93.41	46.31	60.89	11.61
Mar. 2017	16.8	19.7	143.36	7.41	7.16	0.55	140.95	89.56	47.91	60.97	11.18
Apr. 2017	23.1	24.5	142.29	7.37	6.81	0.54	141.35	87.35	44.31	59.16	12.23
May. 2017	27.1	28.7	141.39	7.32	6.58	0.37	139.72	92.57	42.19	59.77	11.67
June. 2017	30.2	31.2	137.48	7.34	6.18	0.06	136.47	89.14	38.37	58.23	11.38
July. 2017	29.5	30.7	135.82	7.35	6.43	0.08	137.08	90.97	39.66	58.18	11.13
Aug. 2017	29.3	31.1	136.59	7.37	6.73	0.28	138.81	91.1	42.32	59.09	12.23
Sep. 2017	30.5	30.6	137.06	7.38	6.74	0.5	137.27	87.22	41.07	58.38	12.58
Oct. 2017	26.8	27.7	141.01	7.41	6.83	0.44	140.29	86.41	43.33	58.79	12.39
Nov. 2017	15.9	22.7	141.97	7.43	7.19	0.47	139.96	92.03	43.83	59.29	10.26
Dec. 2017	13.7	19.4	143.25	7.42	7.24	0.49	140.35	90.87	43.61	60.37	11.19
Jan. 2018	13.6	17.2	143.96	7.43	7.34	0.51	139.41	89.39	45.37	60.33	11.52

Pre monsoon

Monsoon

Post monsoon

Table no 6: Seasonal variation (pre monsoon, monsoon and post monsoon) of different physico chemical parameters at Doyang Reservoir.

Figure 33A

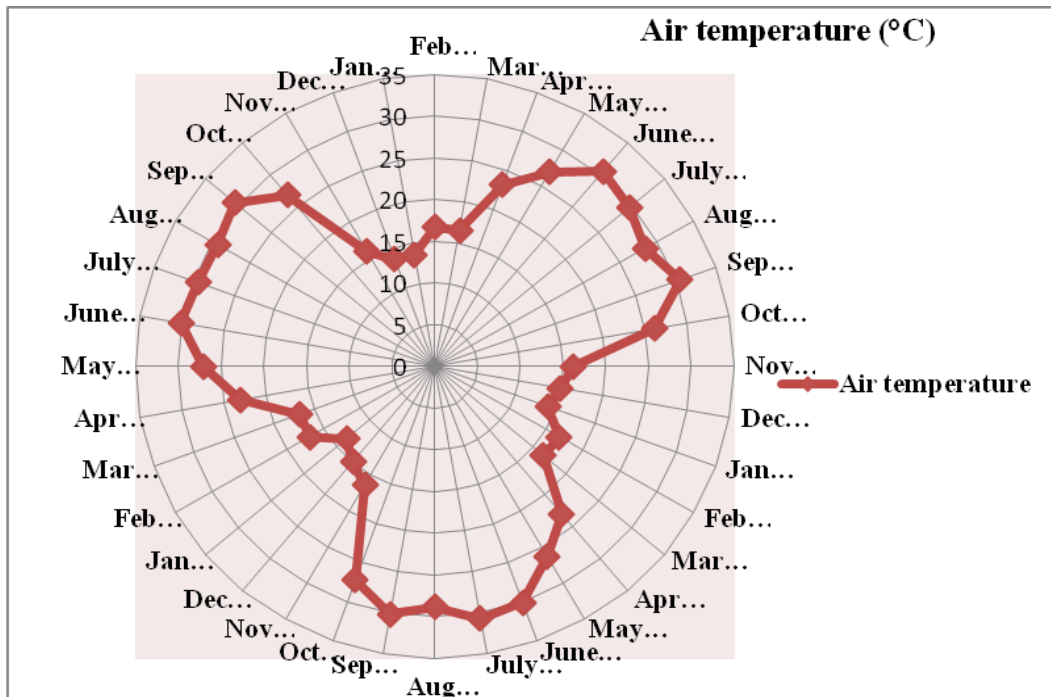


Figure 33B

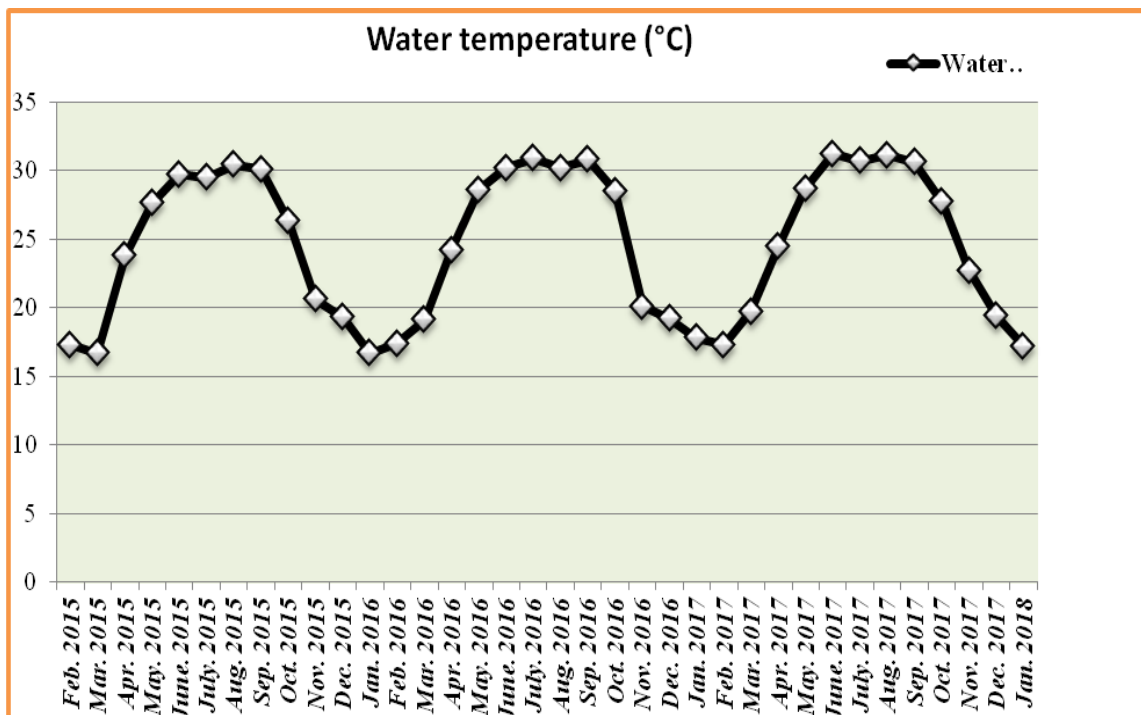


Figure 33 A, B: Monthly variations of Air temperature and water temperature from the duration of February 2015 to January 2018 at Doyang reservoir.

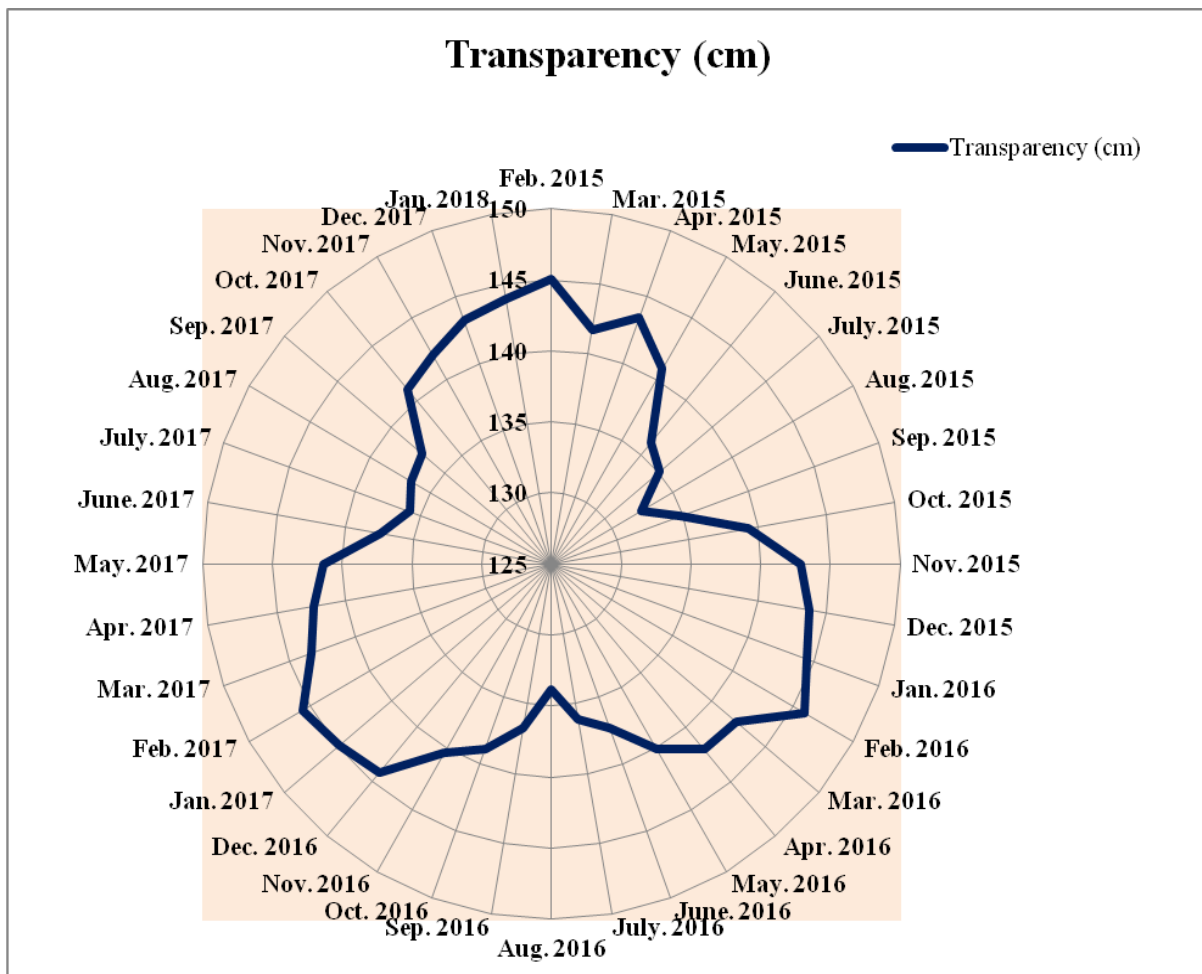


Figure 34: Variation of Secchi depth (water transparency) on monthly basis at Doyang reservoir from Feb. 2015 to Jan. 2018.

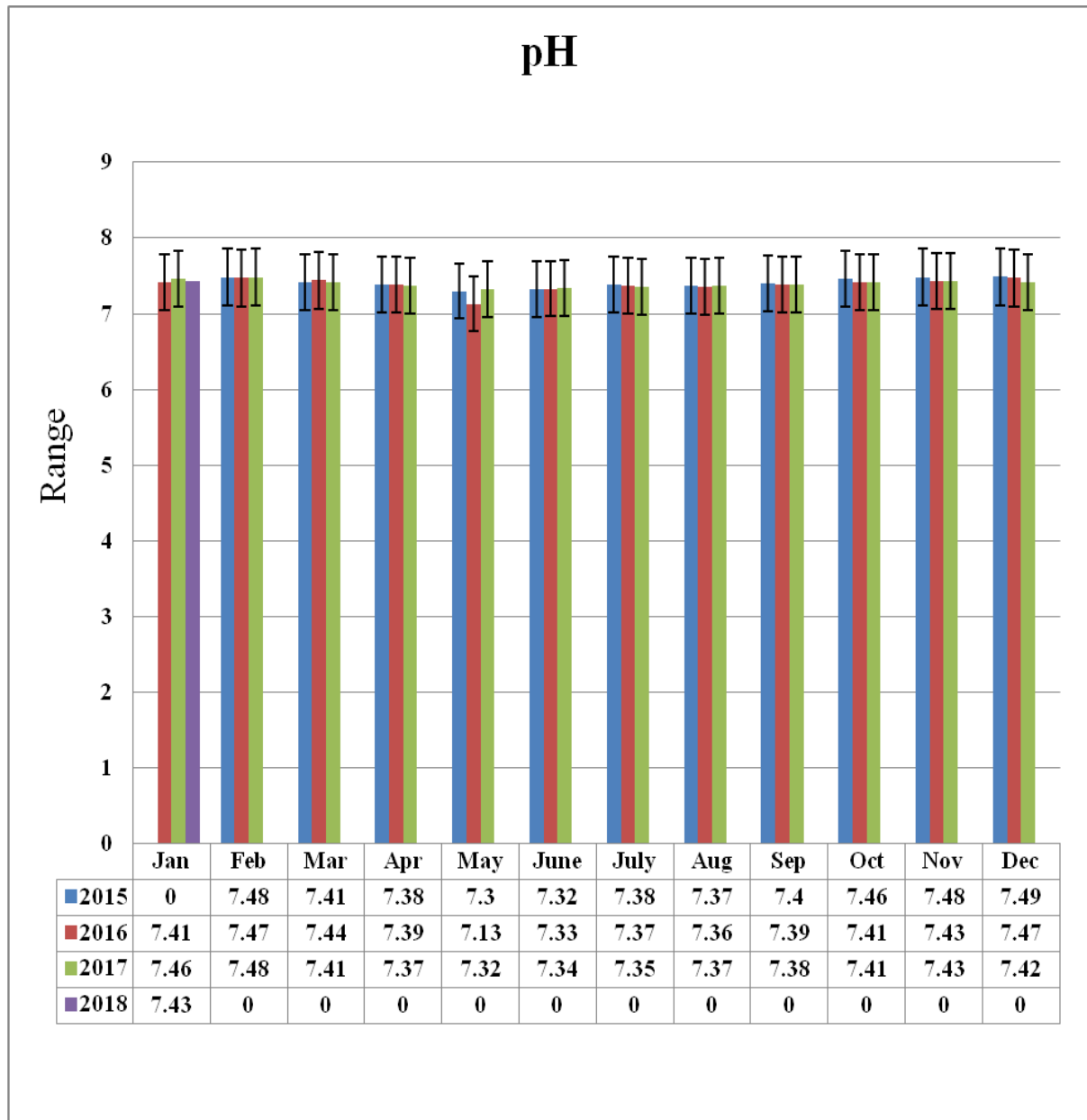


Figure 35: pH range in different time scale during study period at Doyang reservoir.

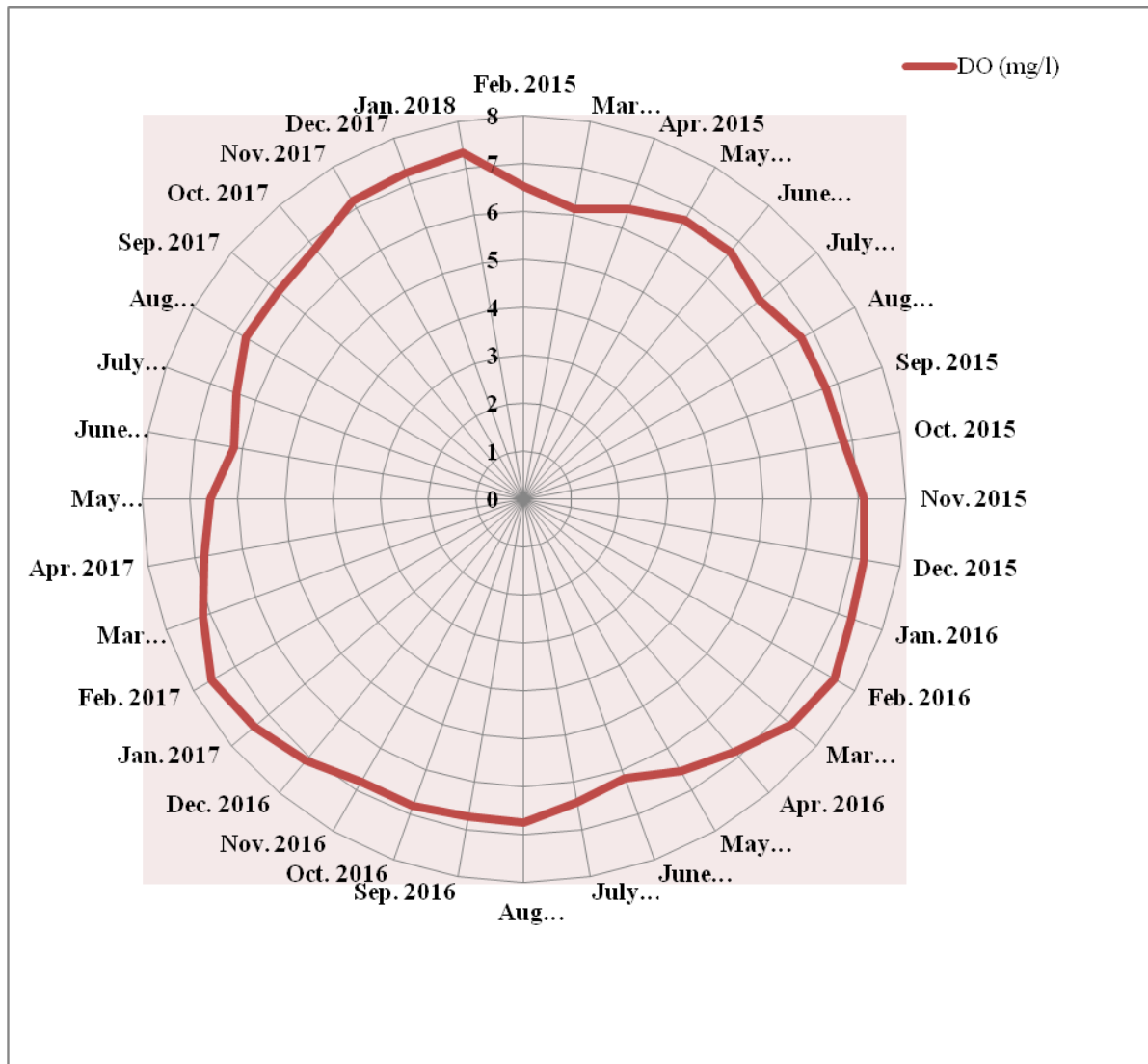


Figure 36: Determination of D.O at Doyang reservoir on different monthly interval.

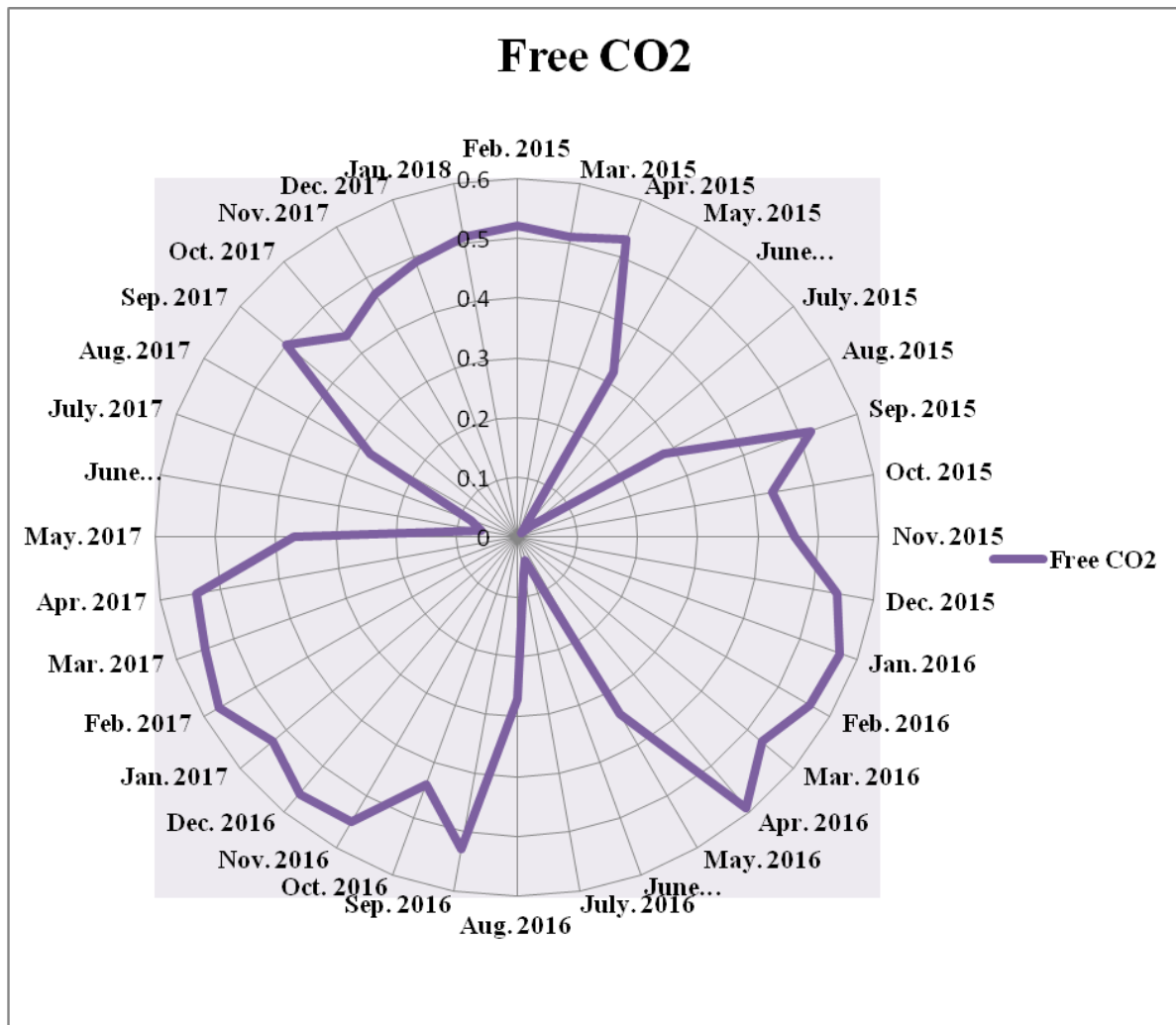


Figure 37: Month wise variations of free CO₂ at Doyang reservoir study sites.

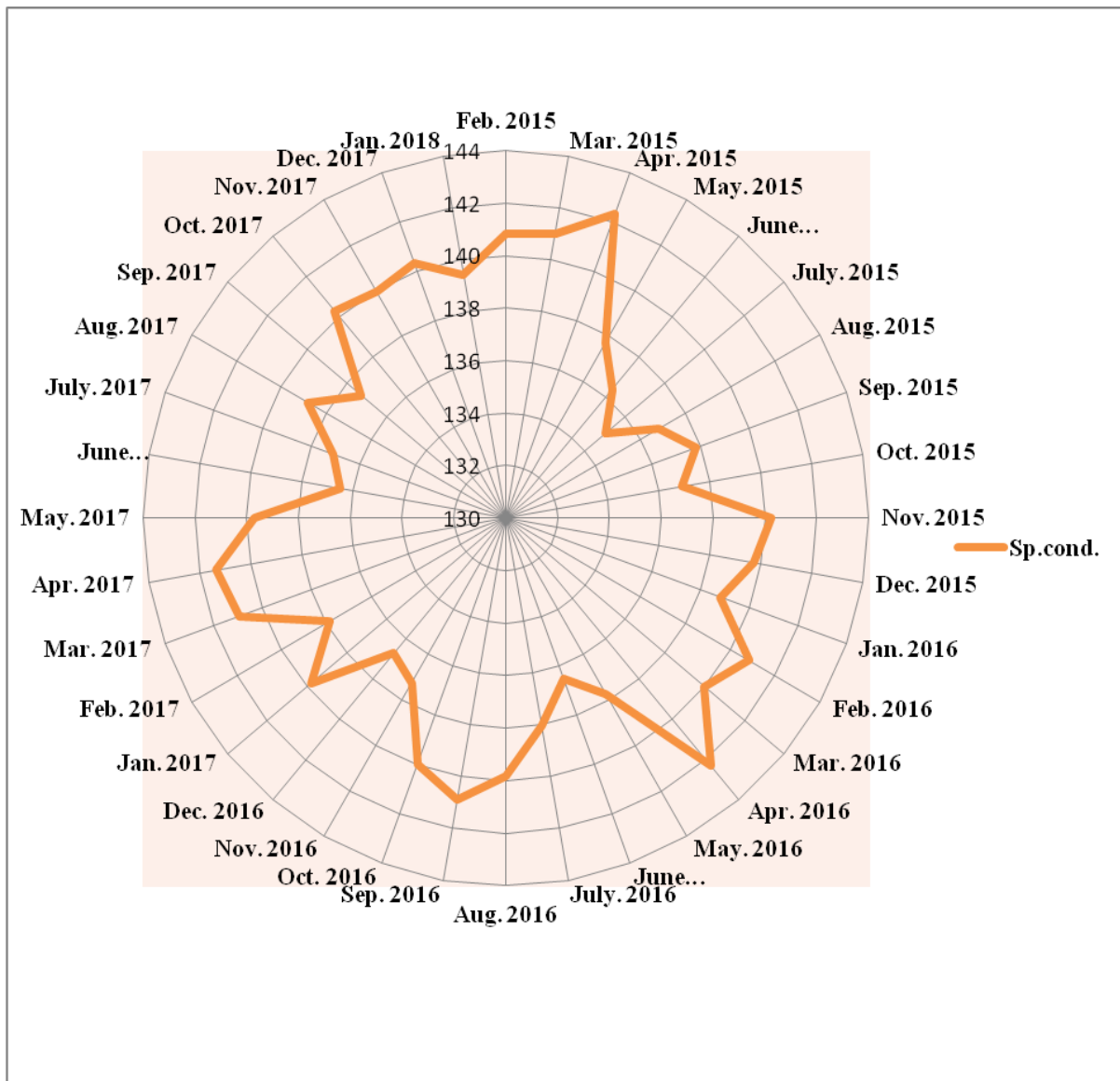


Figure 38: Month wise variations of specific conductivity at Doyang reservoir study sites.

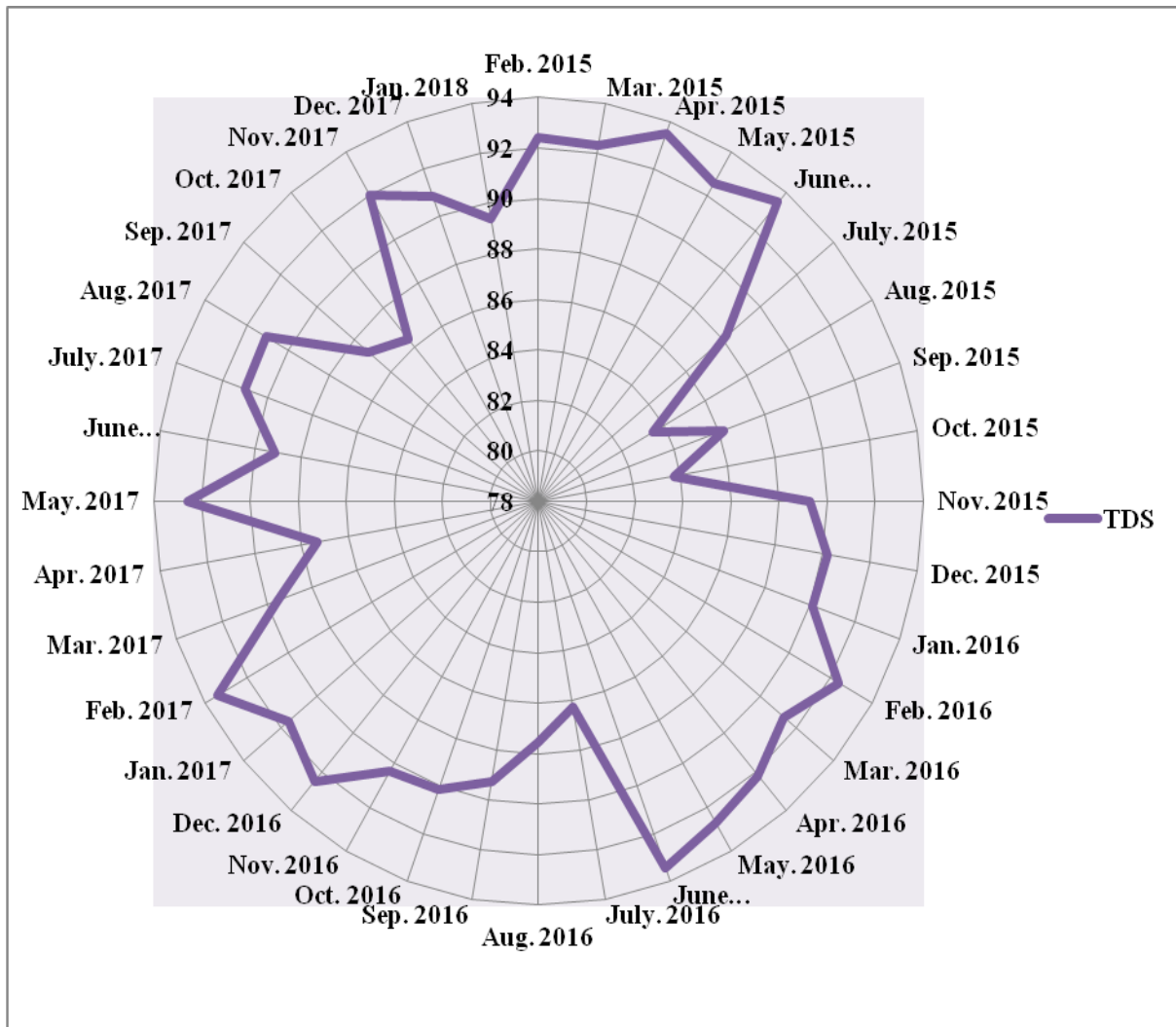


Figure 39: Monthly variations of TDS at Doyang reservoir.

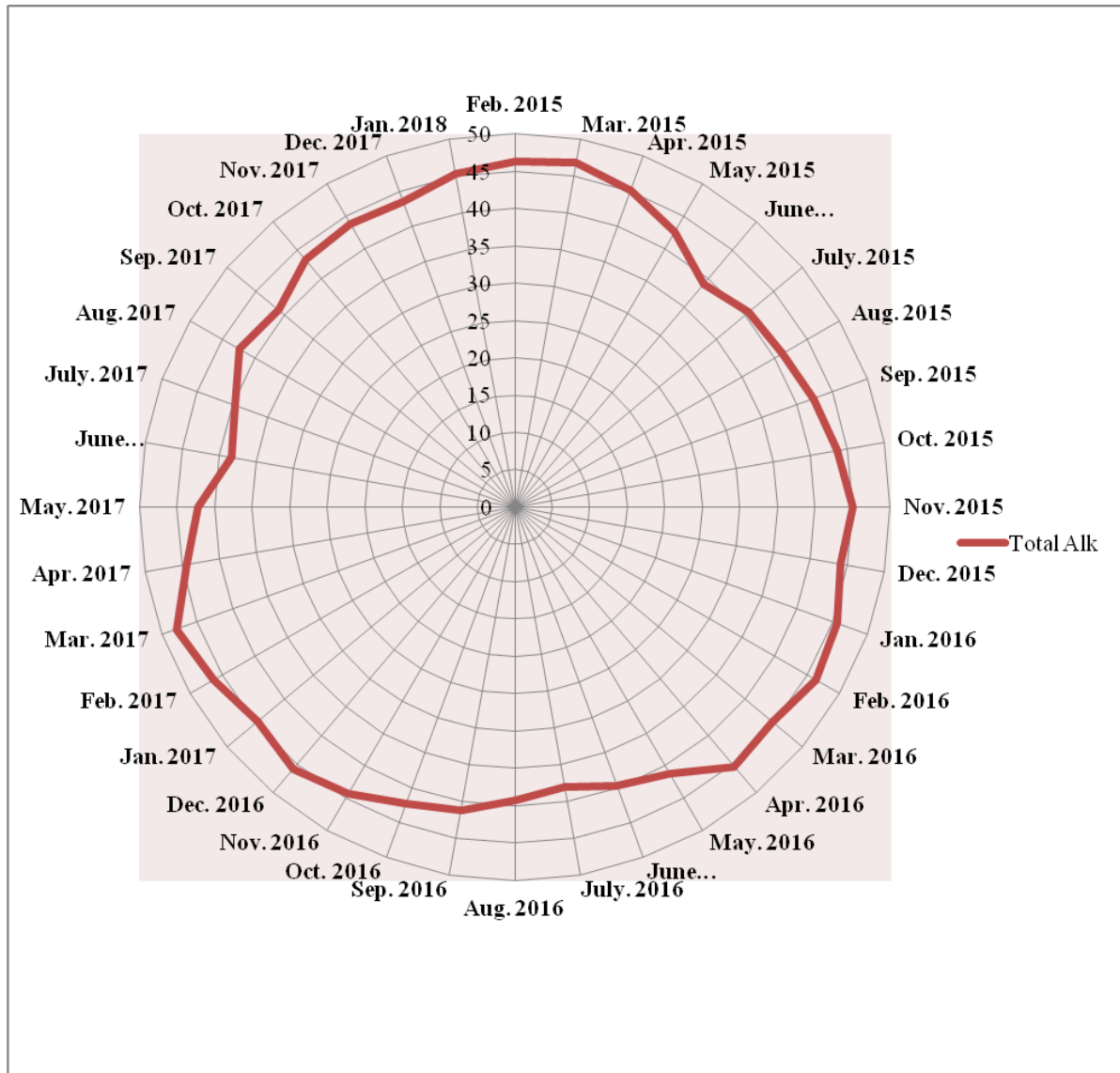


Figure 40: Monthly variations of Total Alkalinity at Doyang reservoir.

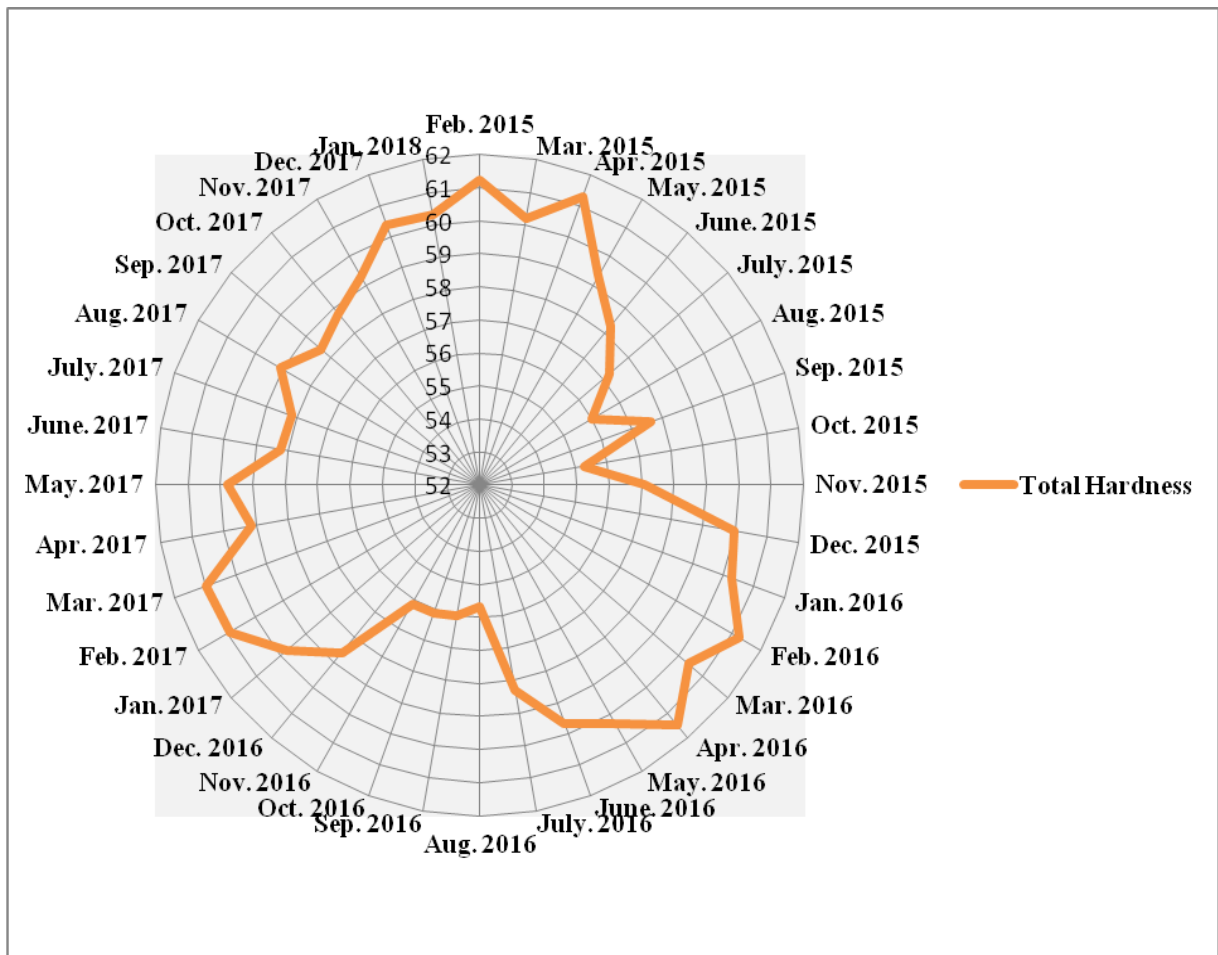


Figure 41: Monthly variations of Total hardness at Doyang reservoir.

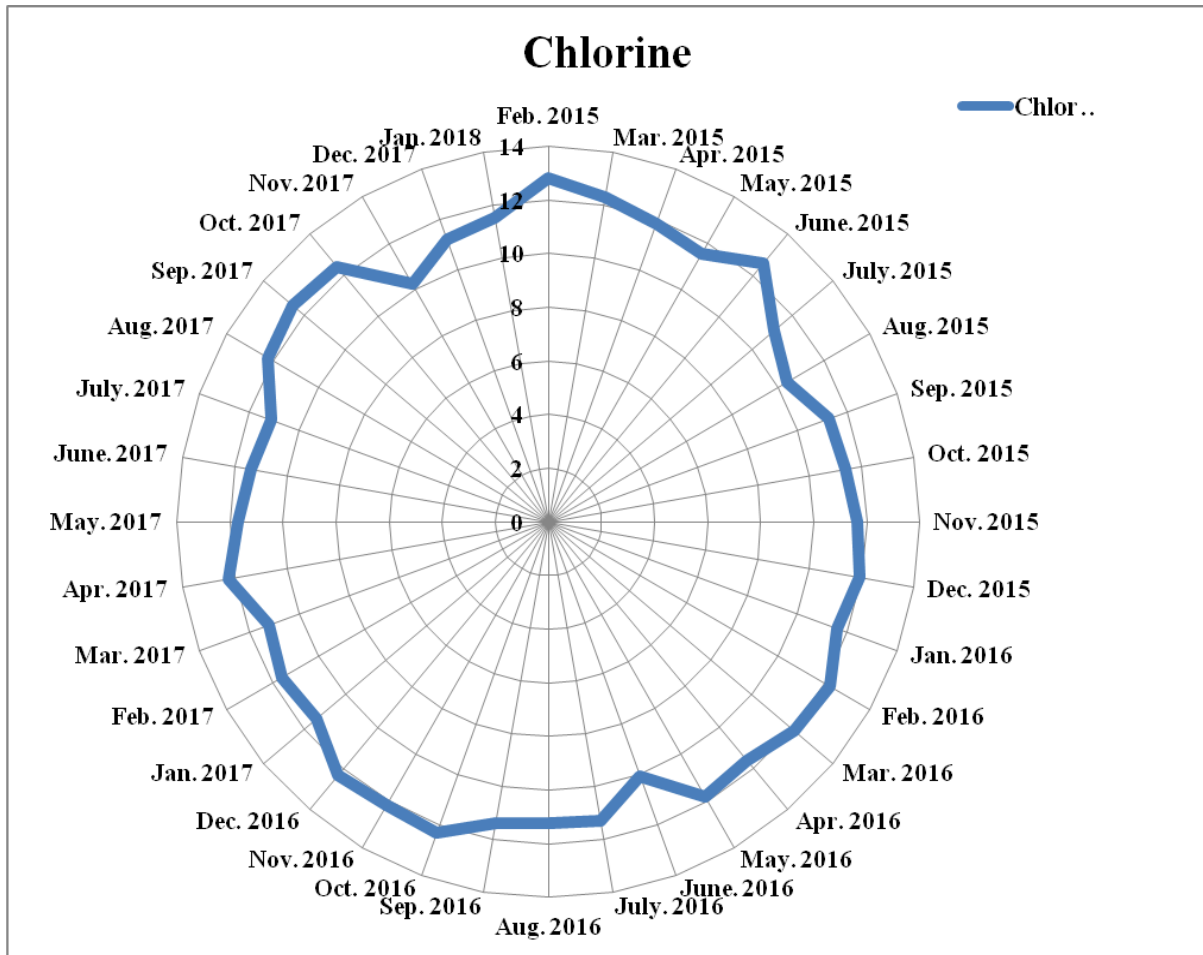


Figure 42: Monthly variations of Chlorine concentration at Doyang reservoir.

Descriptive statistics	Air Temp. (°C)	Water Temp(°C)	Secchi depth (cm)	pH	DO (mg/l)	Free CO₂ (mg/l)	Sp.cond. (µmhos/cm)	TDS	Total Alk. (mg/l)	Total hardness	Cl (mg/l)
Mean	22.828	24.606	140.341	7.396	6.839	0.405	138.973	90.144	43.169	58.918	11.660
Standard Error	1.094	0.911	0.621	0.011	0.063	0.031	0.312	0.451	0.433	0.299	0.107
Median	24.650	25.400	141.200	7.405	6.770	0.495	139.565	90.605	43.610	59.225	11.605
Mode	16.600	17.300	142.290	7.410	6.730	0.530	138.810	92.400	43.610	60.330	12.230
Standard Deviation	6.562	5.469	3.726	0.068	0.381	0.184	1.871	2.708	2.599	1.793	0.641
Sample Variance	43.053	29.907	13.882	0.005	0.145	0.034	3.502	7.334	6.754	3.215	0.411
Kurtosis	-1.768	-1.702	-0.999	5.414	-0.704	-0.059	-0.953	0.050	-0.836	-0.775	0.256
Skewness	-0.170	-0.196	-0.386	-1.621	0.104	-1.150	-0.126	-0.832	-0.291	-0.516	-0.482
Range	17.200	14.500	13.560	0.360	1.440	0.580	7.320	10.010	9.820	6.190	2.750
Minimum	13.500	16.700	132.410	7.130	6.130	0.010	135.020	83.500	38.090	55.280	10.090
Maximum	30.700	31.200	145.970	7.490	7.570	0.590	142.340	93.510	47.910	61.470	12.840
Sum	821.800	885.800	5052.260	266.240	246.190	14.580	5003.010	3245.180	1554.070	2121.030	419.770
Count	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000	36.000
Largest(1)	30.700	31.200	145.970	7.490	7.570	0.590	142.340	93.510	47.910	61.470	12.840
Smallest(1)	13.500	16.700	132.410	7.130	6.130	0.010	135.020	83.500	38.090	55.280	10.090
Confidence Level(95.0%)	2.220	1.850	1.261	0.023	0.129	0.062	0.633	0.916	0.879	0.607	0.217

Table no 7: Description of different common statistical parameters depending on physico-chemical data of Water at Doyang reservoir.

	<i>Air Temp.</i> (°C)	<i>Water Temp</i> (°C)	<i>Secchi depth</i> (cm)	<i>pH</i>	<i>DO (mg/l)</i>	<i>Free CO₂</i> (mg/l)	<i>Sp.cond.</i> (µmhos/cm)	<i>TDS</i> (mg/l)	<i>Total Alk.</i> (mg/l)	<i>Total hardness</i>	<i>Cl</i> mg/l)
Air Temp. (°C)	1										
Water Temp (°C)	0.969970748	1									
Secchi depth (cm)	-0.855108474	-0.879437098	1								
pH	-0.613981504	-0.635292726	0.478316609	1							
DO (mg/l)	-0.689266646	-0.64095776	0.604876093	0.559229278	1						
Free CO₂ (mg/l)	-0.686567234	-0.694953627	0.695260728	0.530403963	0.61594887	1					
Sp.cond. (µmhos/cm)	-0.424289638	-0.432835987	0.532539035	0.282418308	0.271471587	0.638020873	1				
TDS (mg/l)	-0.33847773	-0.362684289	0.499872105	-0.099942814	0.083586622	0.089775877	0.206494492	1			
Total Alk. (mg/l)	-0.829003667	-0.876548543	0.838106213	0.59025122	0.575343546	0.839526516	0.566173926	0.281304	1		
Total hardness	-0.492900492	-0.54967869	0.697395182	0.036645934	0.260009222	0.326091338	0.446602188	0.640846	0.532756087	1	
Cl (mg/l)	-0.144287363	-0.243704521	0.323833565	0.145100902	0.066291574	0.330966071	0.234391116	0.200294	0.296574727	0.177112068	1

Table no 8: Co-relation data matrix between all measured physico-chemicals parameter of water in Doyang reservoir.

Figure 43A

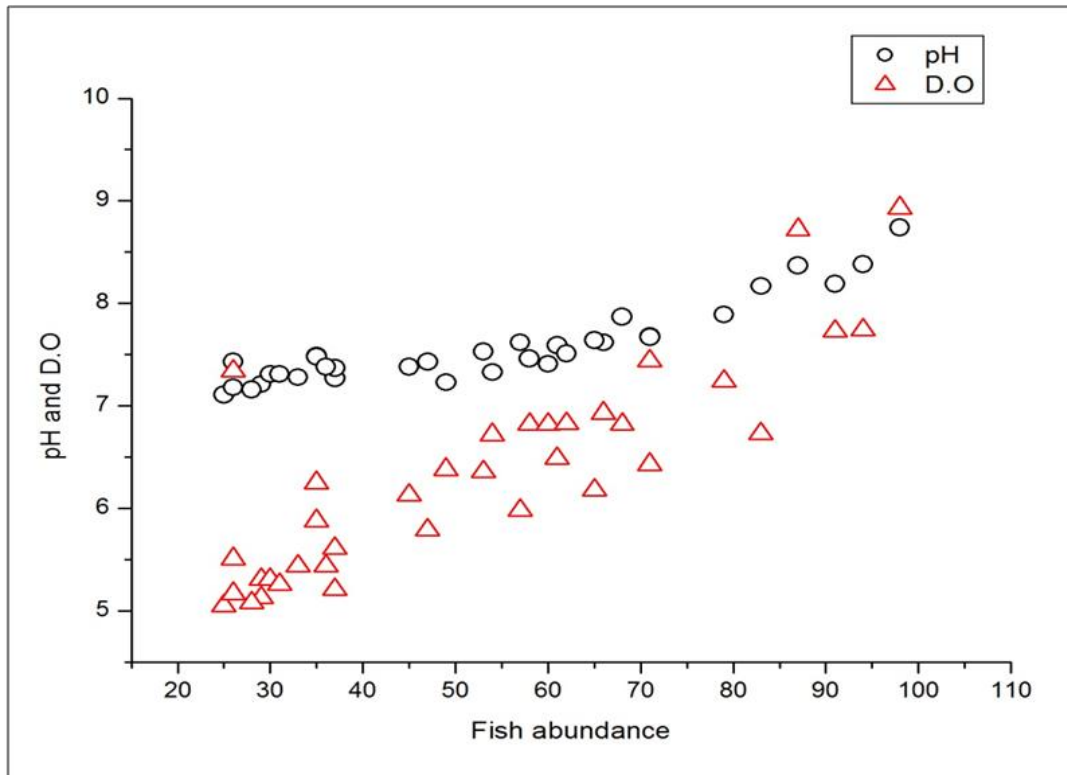


Figure 43B

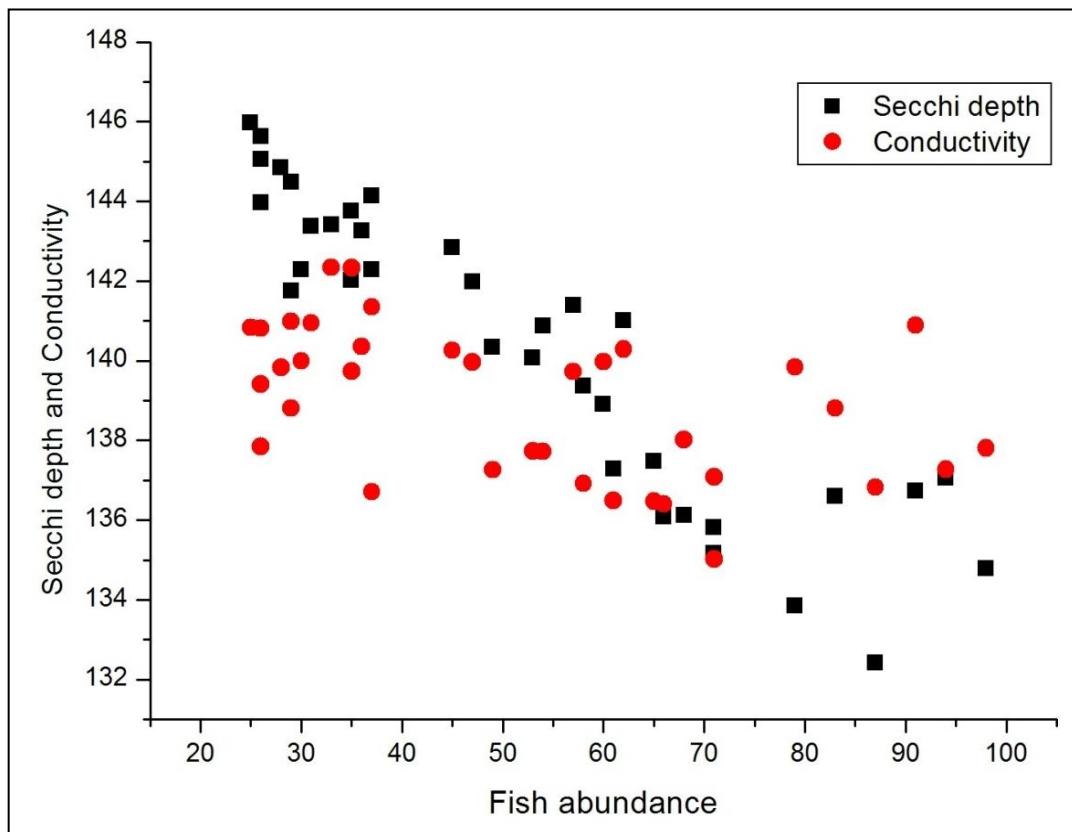


Figure 43C

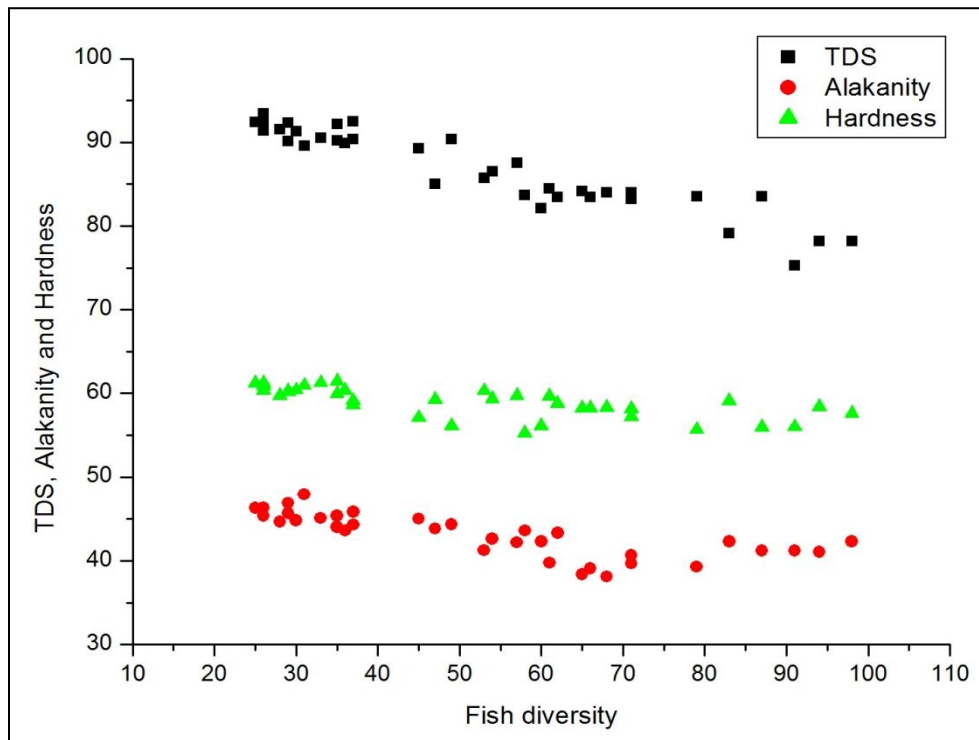


Figure 43D

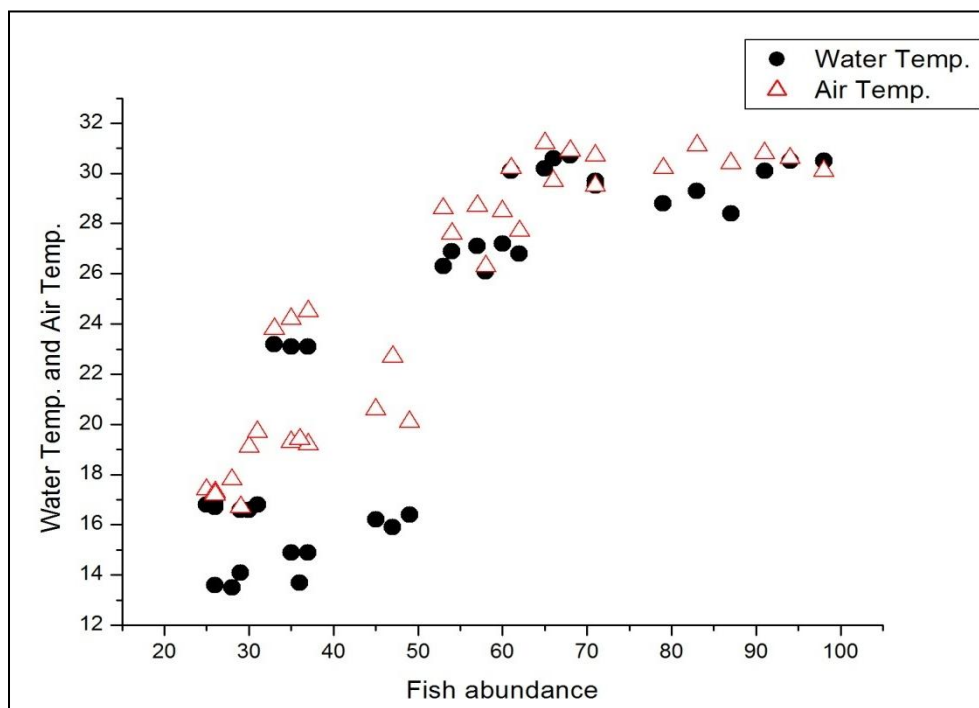


Figure 43(A-D): Correlation between fish abundance and measured water qualities (pH, D.O, T.D.S, Temperature, Conductivity etc.) at Doyang reservoir during entire study periods (Feb. 2015 to Jan. 2018).