Assessment of Water Quality of Inle Lake and Four Main Streams Flowing into Inle Lake ,in Myanmar

Ma Ei Wai Phyo
PhD Candidate
Civil Water Resource Engineering
Yangon Technological University
Yangon , Myanmar
email: eiwaiphyo38@gmail.com

Outlines of Presentation

- Study Area
- Objectives of the Study
- Conceptual Framework for study
- Assessment of Water Quality of Inle Lake
- Comparison results from measuring lake water quality using drones(RT4 boat)

  (Source: Measuring lake water quality using drones, R.T. de Lange the Delft University of Technology)
- Assessment of Water Quality of four main streams flowing into the inle lake
- Discussion and Conclusion

Figure. Inle lake

Study Area

- Inle lake is one of the most important watershed areas which is a highly attractive natural heritage place in Myanmar.
- It is a freshwater lake located in the Nyaung Shwe Township of Taunggyi District of Shan State in Myanmar.
- It is the second largest lake in Myanmar with an estimated surface area of about116km2, and one of the highest at an elevation of 884m.
- (It is located within 96°46́ - 97°.09´ E longitude and 20°05´- 21°17´N latitude in WGS 84 coordinate system.)

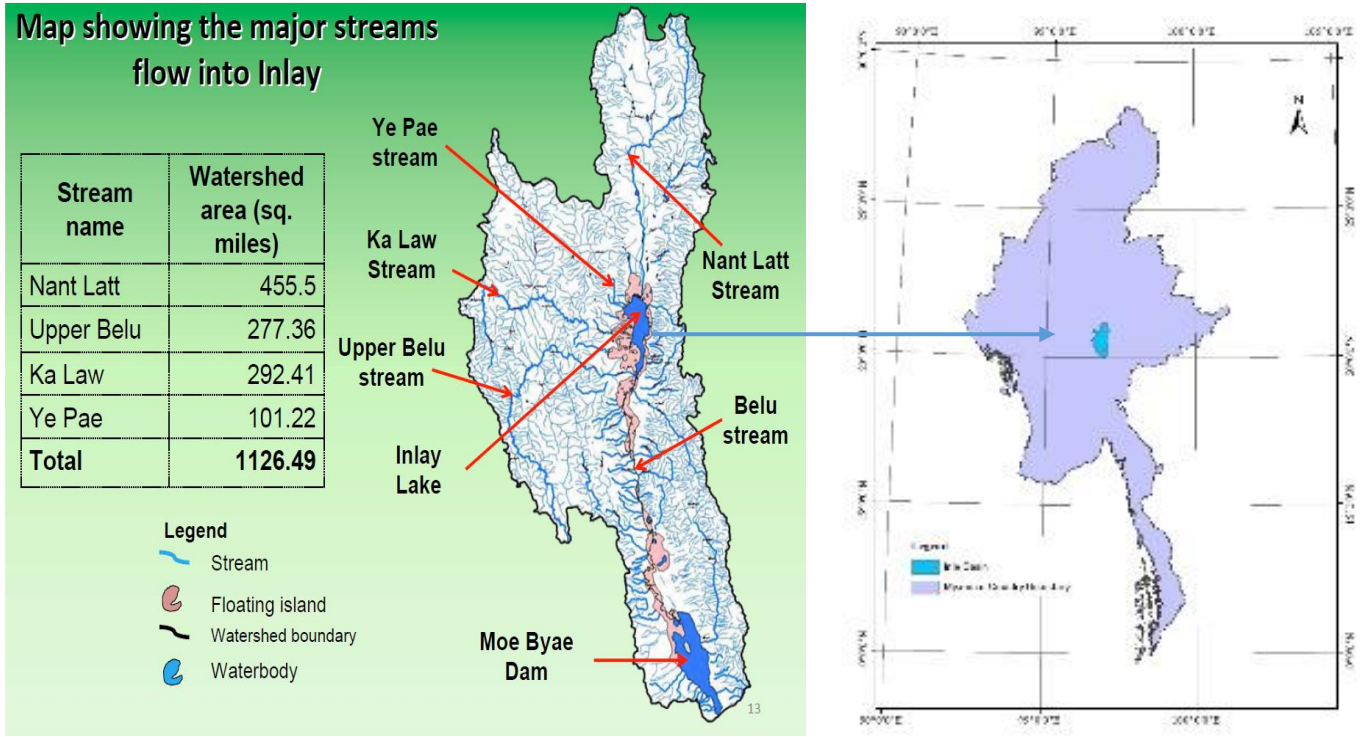


Fig of study area of Inle basin (Source: MOECAF2014)

Villages Around Inle Lake

- There are **35** village tracts within Nyaung Shwe Township. Of these, **17 lie within the lake and 5 lie partly in the lake and partly on land.**
- The remaining 13 village tracts are situated in the lake surroundings.
- Population is about 1 lakh (105533nos,1995) and now,it increased about 60percent within 25years.

Table. General information of villages ,Nyaung Shwe(2019)
(Source; Department of Rural Development, Shan State Development Committee)

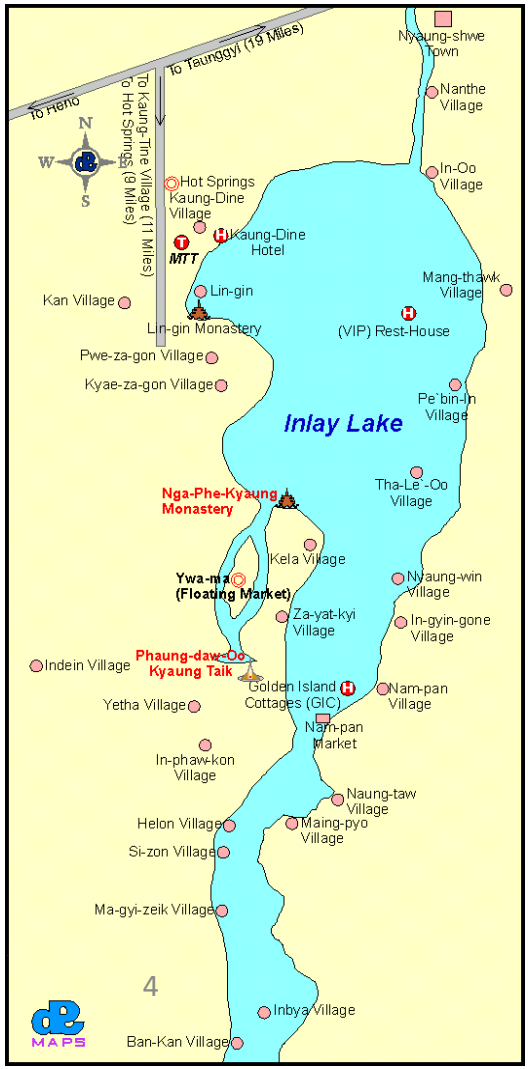


Fig of Villages around Inle lake (source: DPS)

No.	Main Village Name	Sub Group Number	Housing No.	Population
1	Nan Thae	8	790	4566
2	Kyun Gyi	6	940	5640
3	Linn Kinn	14	1022	4689
4	Khaung Tine	5	729	3299
5	Lat Maung Kway	8	606	2663
6	Taung Poet Gyi	14	861	3859
7	Taung Chay	24	1389	5990
8	Mine Thauk	17	1166	5599
9	Ywar Thar	11	893	4292
10	Ti Law	27	2839	13598
11	Min Chaung	12	1844	10396
12	Nann Pan	11	967	3973
13	Tone Lal	9	1040	3979
14	Tha Pyay Pin	9	1267	5460
15	Nga Phal Chaung	8	651	2896
16	Ywar Ma	13	818	3115
17	Thar Layy	13	988	4886
18	Mine Pyoe	11	430	2171
19	Naung Taw	26	1630	7714
20	Inn Hlyar, Kyaing Kham	14	964	4750
21	Taung To	22	1015	5102
22	Kyauk Tine	11	577	2924
23	Kyay Paw Khone	15	1518	7563
24	Inn Tain	6	820	3709
25	Inn Chan Kay Lar	6	1060	5169
26	Inn Paw Khone	13	936	4720
27	Tha Lae Oo	25	1408	5953
28	San Karr	9	749	3885
29	Lone Kan	9	632	3957
30	Yae Puu	4	421	2024
31	Linn Lan Taung	6	613	2997
32	Inn Tann	9	456	2259
33	Bann Pyin	19	1405	6340
34	Linn Lan Myauk	7	648	3418
35	Pone Muu	24	1200	5771
	Total	445	35292	169326

Objective of the Study

- The Inle Lake is reported to have faced a serious decline in open water surface area and water quality reduction in the recent years. (Furuichi & Wasson, 2011; Michalon et al., 2019; Sidle et al., 2007).
- The research objective is to assess the present status of water quality in Inle Lake seasonally and spatially.

- (The analysis can help to identify the main sources of pollution and serve as a basis for measures against the contamination of the freshwater resources to preserve biodiversity and secure access to clean water for the population at the Inle Lake.)

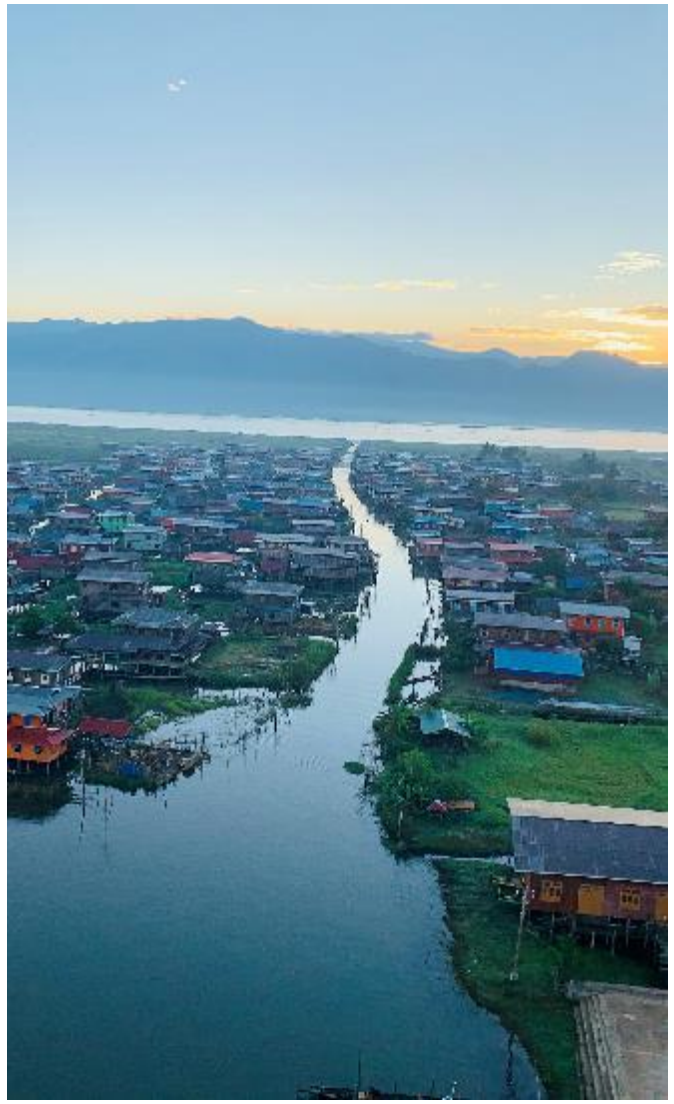
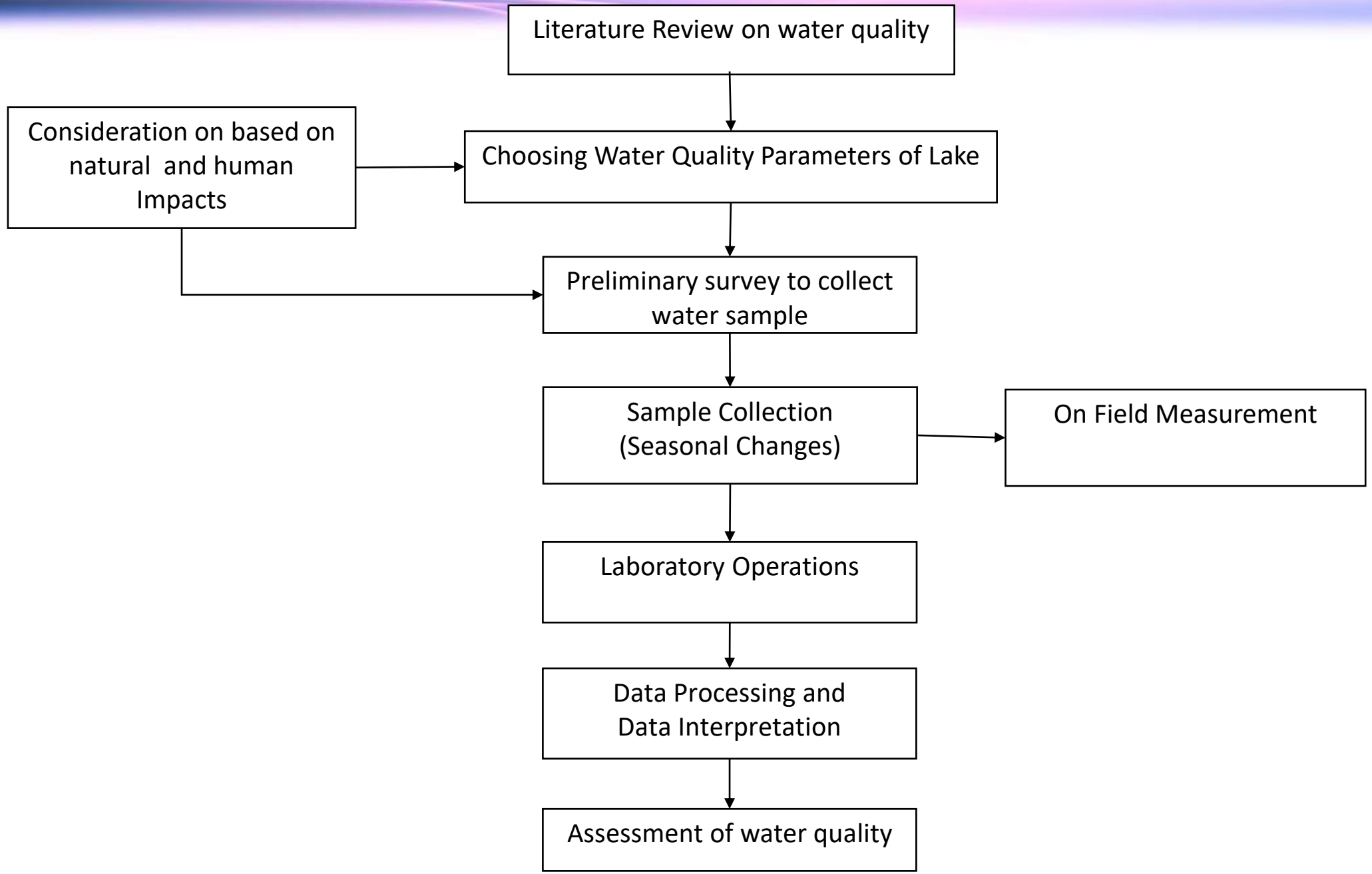


Fig. Village of Inle lake

Figure. Flow Chart for Assessment on Changes of Water Quality in Inle Lake



Water Quality Measurement

- To consider the comprehensive measures, a total of three water quality measurements in the lake were undertaken in **December** 2019(the first) , **February** 2020 (the second) and **March** (the third).




Fig. Water Quality Measurement Team

Table. Data of Water Quality Measurement Team

No of Survey	Time	Participants	Station
First	Dec	• B.E(Civil) students, WYTU • Local ambassador (MIID) • Local people	8 Stations in Inle Lake
Second	Feb	• Professor , YTU • Officer , Ministry of agriculture and irrigation ,irrigation department ,Nyaung Shwe • MSc Civil Engineering Water Management student, the Delft University of Technology , The Netherlands • Local ambassador (MIID) • BE(Civil) students , WYTU	8 Stations in Inle Lake and 4 main streams stations
Third	March	• M.Sc. Environmental Management student, Kiel University , Germany • BE(Civil) students , WYTU • Local ambassador (MIID) • Master Students , Taungyi University • GIZ team • Local people	8 Stations(in Inle Lake) and 4 main streams

Factors Influence on water quality in Inle Lake

Water quality of Inle lake is influenced by many factors:

- Climatic Condition
- Geology
- Agriculture Practices
- Population Growth
- Urban Development
- Water usage
- Waste management system
- Sedimentation
- Local Business , etc.

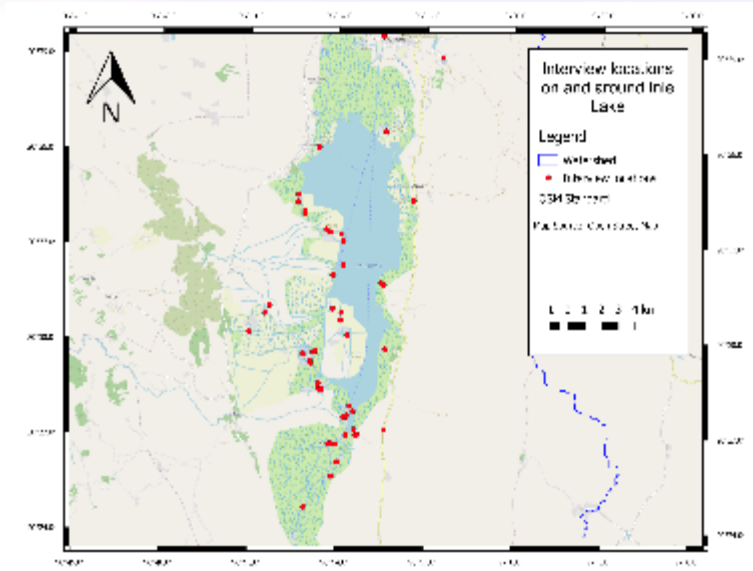









Fig. Map of Interview locations on and around Inle Lake and environmental survey

Water Quality Parameter

The water samples were collected for three time and all samples transported to Alarm Ecological Laboratory (Yangon) during 24 hours for analysis. There are 18 water quality parameters measured .

Physical Characteristics

1. Temperature
2. Turbidity
3. TDS
4. TSS
5. TS
6. Conductivity
7. Color

Chemical Characteristics

1. pH
2. Total Hardness
3. DO
4. COD
5. Nitrate-Nitrogen
6. Total Alkalinity
7. Manganese
8. BOD
9. Arsenic
10. Phosphorous

Biological Characteristic

1. Total Coliform

Fig. Preparation water samples to send Inle lake to Alarm ecological lab, Yangon

Figure of Instruments Used for Collection Water Sample

1. Sterilized Bottle
2. Icebox
3. Sampler
4. Hawkeye Sonar
5. CDT Diver & Cup
6. GMH3400 Meter[69]
7. Multimeter instrument
   (Senso Direct150)

8. RT4 equipped with measuring devices (only second time)

1


2


3


4


6


5


7


8


During the field survey, some physicochemical parameters (pH, temperature, TDS, conductivity and DO) were measured in situ. At second time, spatial water quality measurement was made around 8 stations by Rt4 bait boat equipped with measuring devices (source: Robbert De Lange 2020)

Stations for Water Sample Collection

- There are eight stations in Inle lake and four main stream stations based on environmental survey.

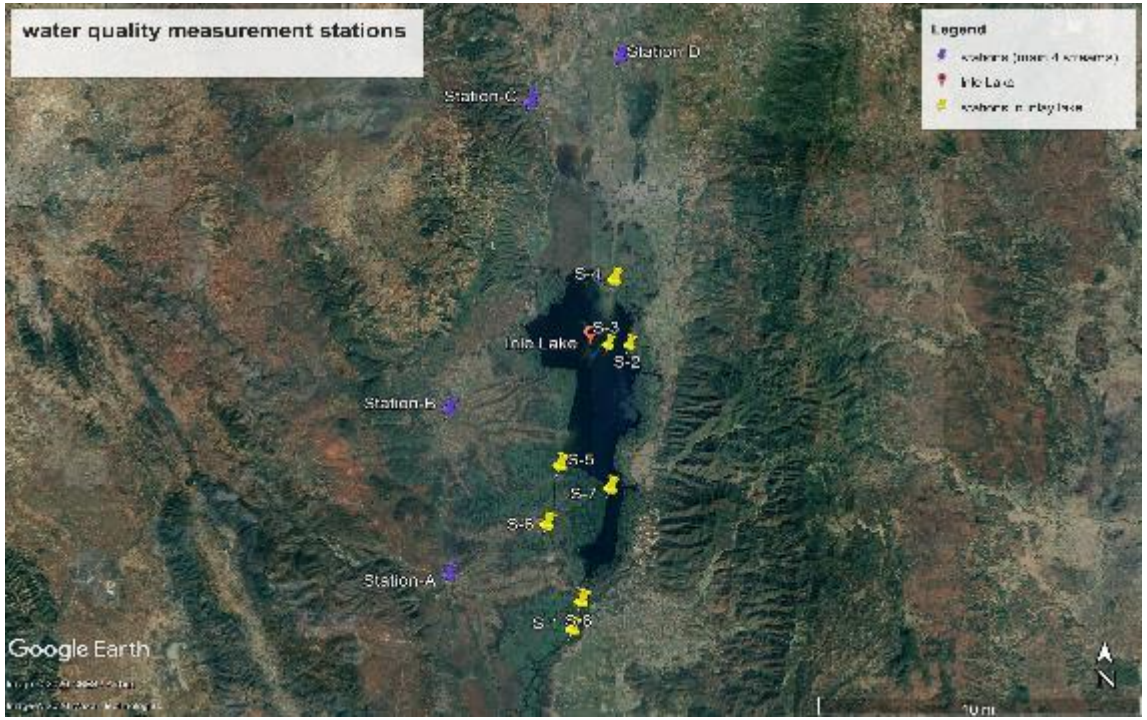


Fig. water quality measurement stations

Table . Location of stations to collect water sample Inle lake)

No.	Locations	Latitude (N)	Longitude (E)	Reasons
S-1	Maing-Pyo Village	20.4327	96.8996	near outflow
S-2	b/w Sky lake &Paradise Hotel	20.5773	96.9272	b/w two floating hotels
S-3	Rest House	20.57738	96.9271	center of lake
S-4	Nyaung Shwe's Canal	20.6092	96.9196	Inflow
S-5	Nga- Phe -Chaung	20.5162	96.8936	chemical free zone
S-6	Ywar Ma Village	20.4857	96.8873	gold /silver smith
S-7	Kay La Village	20.5040	96.9177	floating garden
S-8	Inn Paw Khone Village	20.4467	96.9039	weaving village
S-A	Indein Weir	20.4601	96.8403	inflow of Inle lake
S-B	Kalaw stream	20.5438	96.8402	inflow of Inle lake
S-C	Yay Pel Stream	20.6985	96.8402	inflow of Inle lake
S-D	Nant latt Stream	20.712	96.9222	inflow of Inle lake

Station 1

- Location - Maing Pyo village(W/L)
- Reasons - Near outflow of Inle Lake
- (Sub-group of villages- 11
- No of Housings-about 430 ,
- Population – about 2171 nos.)

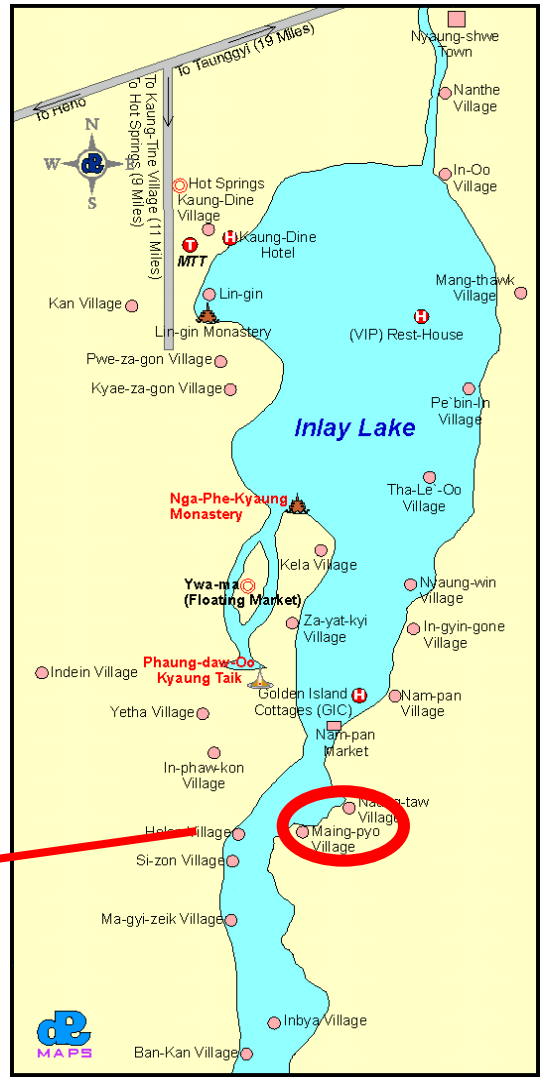


Fig. Environment of station 1

Table. Water Testing Result for Station-1

Nos.	Quality Parameters	Water Sample Result(Dec)	Water Sample Result(Feb)	Water Sample Result(March)	Units	Drinking Standards
1	Temperature	24.057	22	24.5	'C	
2	pH	7.3	7.29	7.15	S.U	6.5-8.5[b]
3	Color	61	31	79	HU	-
4	**Turbidity**	**9**	**6**	**15**	FAU	≤5[b]
5	TDS	226	245	217	mg/L	≤500[b]
6	TSS	9	7	16	mg/L	-
7	Total Solids	235	302	221	mg/L	-
8	**Conductivity**	**0.4**	**0.324**	**0.3**	**mS/cm**	≤2.5[b]
9	**Hardness**	**200(vh)**	**278(vh)**	**140(h)**	mg/L	≤500[c]
10	Phosphorus	4.3	0.12	<0.02	mg/L	-
11	Arsenic	0.005	0	0	mg/L	≤0.01[a]
12	Manganese	<0.2	<0.01	0.37	mg/L	≤0.4[c]
13	Alkalinity	185	430	147	mg/L	-
14	**Dissolved Oxygen**	**5.8**	**5.8**	**5.23**	**mg/L**	-
15	BOD	3.2	<3	3.1	mg/L	-
16	COD	<30	<30	<30	mg/L	-
17	Nitrate-Nitrogen	<1	0.6	0.7	mg/L	-
18	Total Coliform	>1100	>1100	>1100	MPN/100ML	

(Source: Alarm Ecological Laboratory)

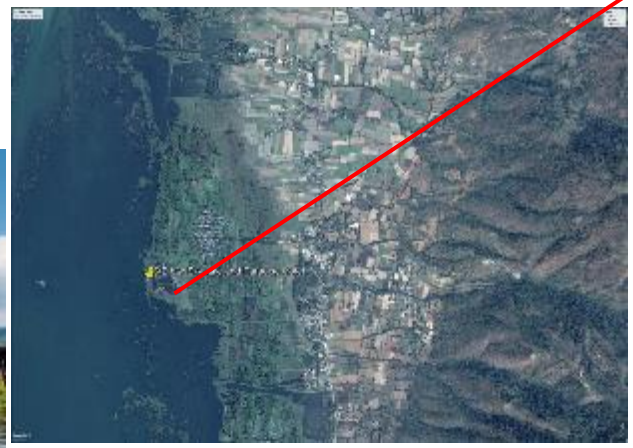
Fig.WQM at station -1
(source :Measuring lake water quality using drones, R.T. de Lange the Delft University of Technology)

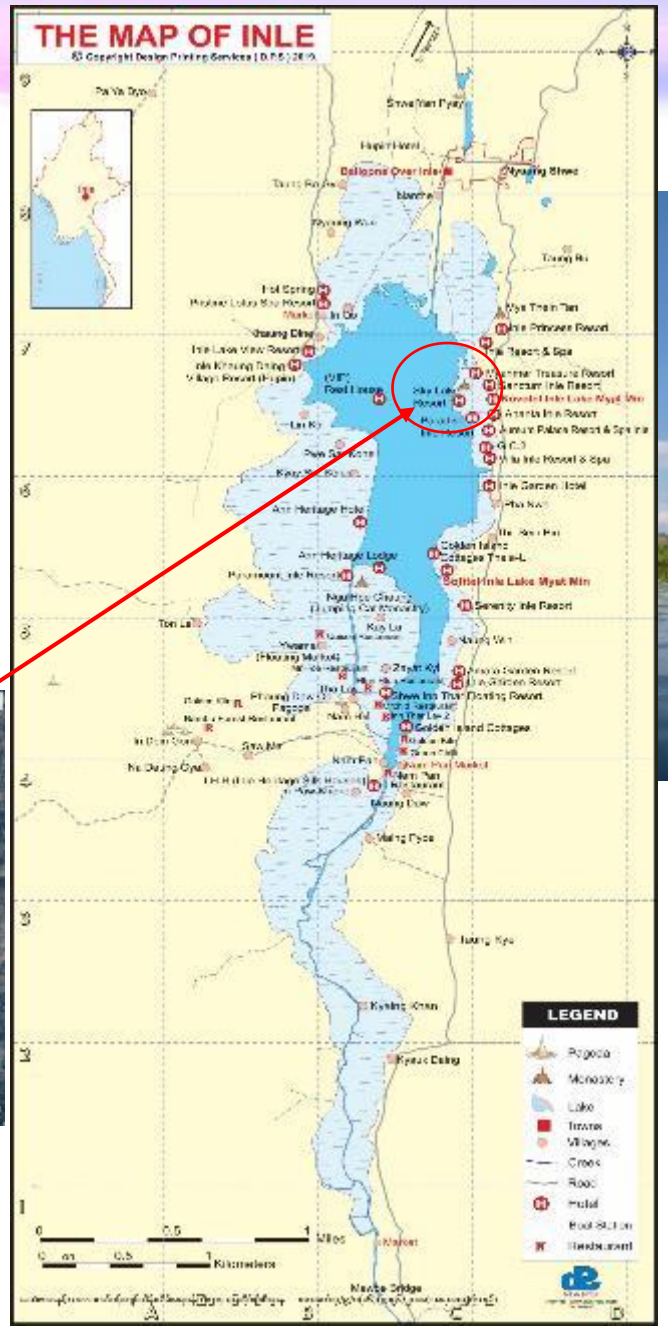
At entrance of Myaing Pyoe Village, the average DO is 7 mg/L. The variations are not really significant, but downstream, it shows a small drop in DO to 6.8 mg/L.

The EC is on average 0.355 mS/cm, and is as the DO quite steady.

Station 2

- Location –Between Sky lake &Paradise Hotel
- Reasons – There are about 17hotels in east side of lake and this two hotels situate at lake surface.





Hyacinths chocked lakeshore and can be seen everywhere in Inle lake .(It can smother aquatic life by deoxygenating the water and it reduces nutrients for young fish)

Fig. Environment of station 2

Table. Water Testing Result for Station-2

Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standards
1	Temperature	24.61	22	27.9	'C	
2	pH	7.4	7.3	7.5	S.U	6.5-8.5
3	Color	3	28	55	HU	-
4	Turbidity	<5	4	<5	FAU	≤5
5	TDS	228	232	239	mg/L	≤500
6	TSS	0	2	4	mg/L	-
7	Total Solids	228	232	229	mg/L	-
8	**Conductivity**	**0.4**	**0.35**	**0.41**	mS/cm	≤2.5
9	**Hardness**	**230**	**299**	**160**	mg/L	≤500
10	Phosphorus	4.8	0.16	0.02	mg/L	-
11	Arsenic	0	0	0	mg/L	≤0.01
12	Manganese	<0.2	<0.01	0.02	mg/L	≤0.4
13	Alkalinity	200	300	190	mg/L	-
14	Dissolved Oxygen	6.8	7.4	7.5	mg/L	-
15	BOD	3.5	4.6	3.2	mg/L	-
16	COD	<30	<30	<30	mg/L	-
17	Nitrate-Nitrogen	<1	2	<0.05	mg/L	-
18	Total Coliform	15	460	210	MPN/100ML	

(Source: Alarm Ecological Laboratory)

Fig. WQM at Inle Lake

Station 3

- Location - Rest House
- Reasons - Centre Point of the Inle Lake

Fig. Environment of station 3

(Source: Alarm Ecological Laboratory)

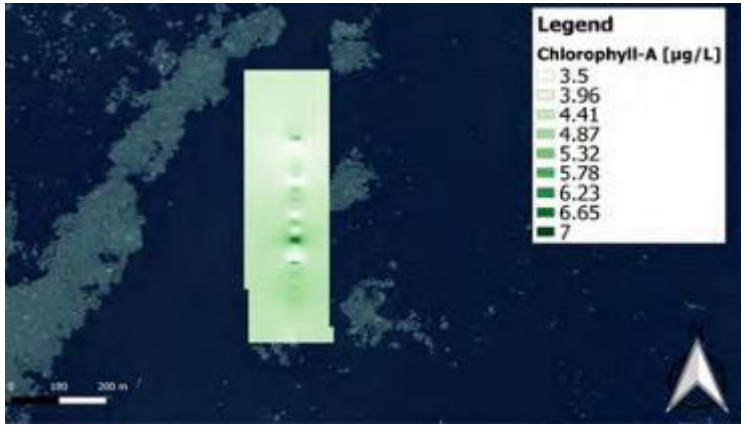
Table. Water Testing Result for Station-3

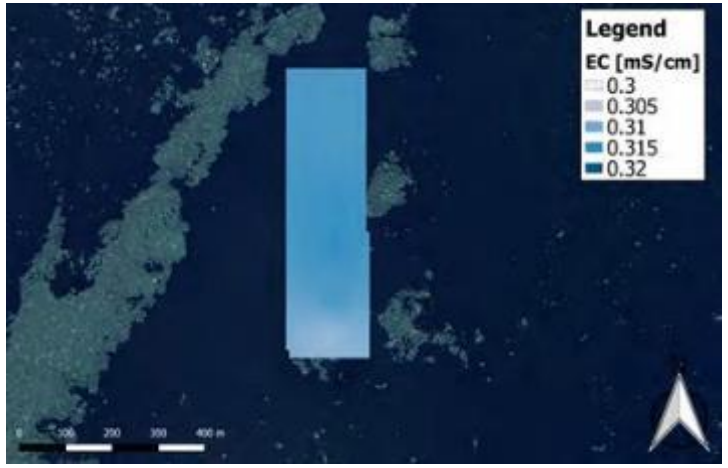
Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standards
1	Temperature	24.873	23	33.3	‘C	
2	pH	7.5	7.7	7.9	S.U	6.5-8.5
3	Color	11	10	11	HU	-
4	Turbidity	<5	6	<5	FAU	≤5
5	TDS	232	212	187	mg/L	≤500
6	TSS	4	0	1	mg/L	-
7	Total Solids	236	187	172	mg/L	-
8	**Conductivity**	**0.4**	**0.3**	**0.3**	**mS/cm**	≤2.5
9	**Hardness**	**200**	**210**	**140**	mg/L	≤500
10	Phosphorus	5.6	0.07	<0.02	mg/L	-
11	Arsenic	0.05	0	0	mg/L	≤0.01
12	Manganese	0.39	<0.01	0.02	mg/L	≤0.4
13	Alkalinity	190	260	131	mg/L	-
14	DO	6.3	7	7.4	mg/L	-
15	BOD	3	3.6	3.2	mg/L	-
16	COD	<30	<30	<30	mg/L	-
17	Nitrate-Nitrogen	<1	<2	<0.5	mg/L	-
18	Total Coliform	15	460	>1100		

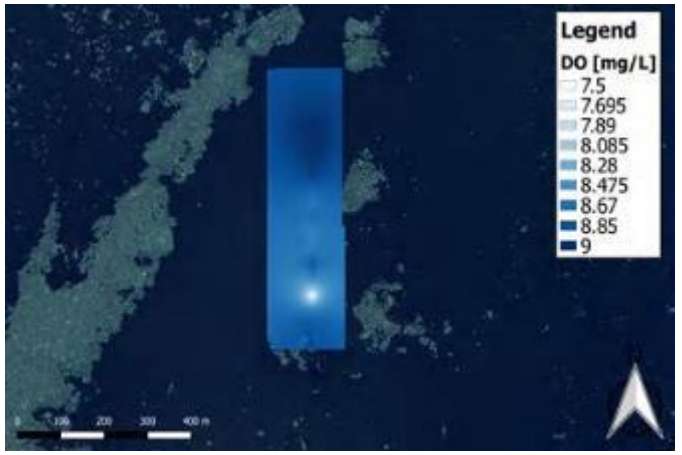
Comparison Water Quality Measurement Using RT4 Near Station3

At the middle of the lake,

- The dissolved oxygen levels are quite low around the middle point. North of the area the DO levels are around 9 mg/L.
- The chlorophyll-A levels are around 5 µg/L and the cyanobacteria levels are around 3 µg/L.







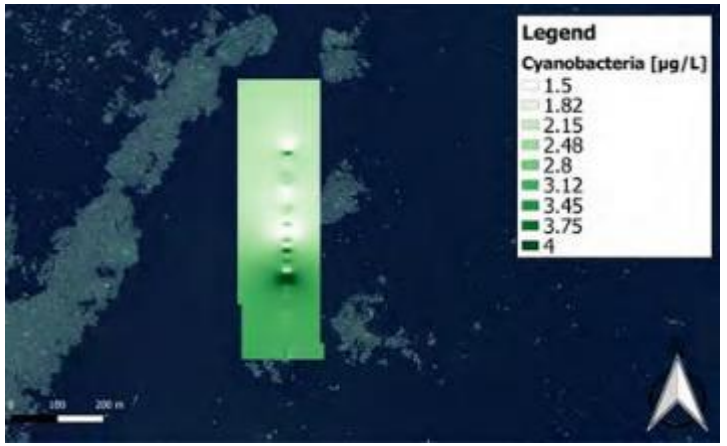


Fig. WQM at station 3 :middle point (source :Measuring lake water quality using drones, R.T. de Lange the Delft University of Technology)

Station 4

- Location –Near Inle Lake Ramsar Site
- Reason - (Nyaung Shwe Canal , inlet of Inle Lake)

Fig. Environment of station 4

Table. Water Testing Result for Station-4

Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standards
1	Temperature	23.643	22	32.68	'C	
2	pH	7.5	7.34	7.18	S.U	6.5-8.5
3	Color	191	950	840	HU	-
4	**Turbidity**	**32**	**241**	**95**	FAU	≤5
5	TDS	289	338	263	mg/L	≤500
6	TSS	31	119	96	mg/L	-
7	Total Solids	320	409	344	mg/L	-
8	**Conductivity**	**0.5**	**0.458**	**0.42**	mS/cm	≤2.5
9	**Hardness**	**260**	**296**	**350**	mg/L	≤500
10	Phosphorus	5.3	0.05	<0.02	mg/L	-
11	Arsenic	0.005	0.005	0	mg/L	≤0.01
12	**Manganese**	<0.2	**0.46**	**0.42**	mg/L	≤0.4
13	Alkalinity	266	390		mg/L	-
14	Dissolved Oxygen	6	5.2	6	mg/L	-
15	BOD	<3	6	4.6	mg/L	-
16	COD	<30	39	<30	mg/L	-
17	Nitrate-Nitrogen	<1	11	1	mg/L	-
18	Total Coliform	1100	>1100	1100	MPN/100ML	

(Source: Alarm Ecological Laboratory

Comparison Water Quality Measurement Using RT4 Near Station 4

- This is the main The electrical conductivity varies from 0.500 to 0.517 mS/cm, where it is lower in the North, upstream.
- The dissolved oxygen levels are around 5.5 mg/L with a maximum level of 5.9 mg/L in the north.
- Chlorophyll-A levels are around 20.6 µg/L and don't vary much.
- The Cyanobacteria levels vary between 4.76 and 5.2 µg/L.

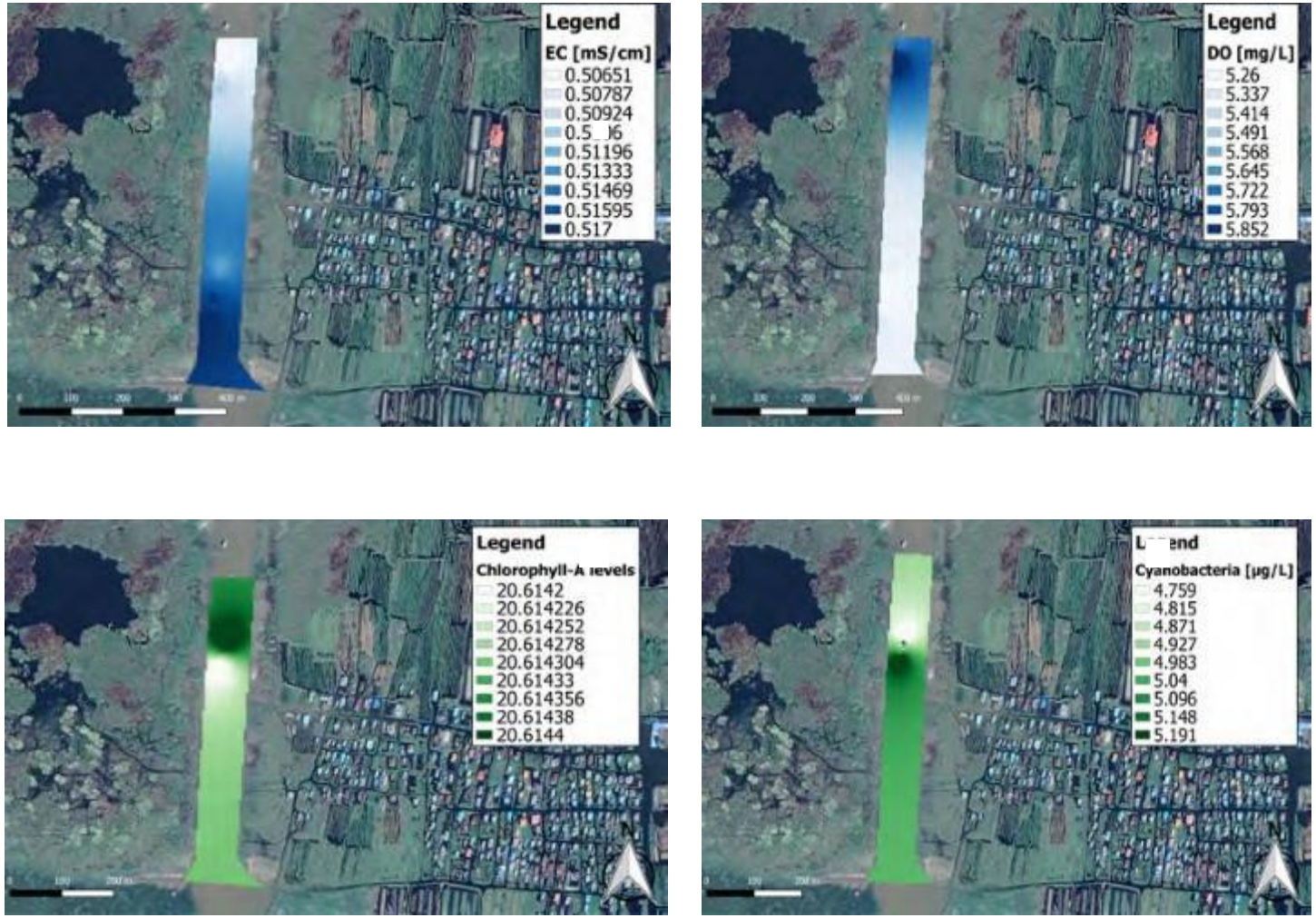


Fig. WQM at station 4 (source :Measuring lake water quality using drones, R.T. de Lange the Delft University of Technology)

Station 5

- Location - Nga Hpe Chaung (stream)
- Reason – one of outflow, Chemical Free Zone, near Phaung Daw Oo Pagoda
- (Group of Villages-8
- No of Housings-about 651,
- population –about 2896nos)

Fig. Environment of station 5

Table. Water Testing Result for Station-5

Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standards
1	Temperature	21.71	21	30.5	‘C	
2	pH	7.5	7.29	7.01	S.U	6.5-8.5
3	Color	22	185	410	HU	-
4	**Turbidity**	<5	86	37	FAU	≤5
5	TDS	268	317	338	mg/L	≤500
6	TSS	0	47	91	mg/L	-
7	Total Solids	268	317	413	mg/L	-
8	**Conductivity**	0.5	0.42	0.5	mS/cm	≤2.5
9	Hardness	280	263	340	mg/L	≤500
10	Phosphorus	5.9	0.04	<0.02	mg/L	-
11	Arsenic	0.005	0.005	0	mg/L	≤0.01
12	Manganese	<0.2	0.16	0.39	mg/L	≤0.4
13	Alkalinity	246	440		mg/L	-
14	Dissolved Oxygen	6.8	5.1	5.5	mg/L	-
15	BOD	3.4	4.6	6	mg/L	-
16	COD	<30	<30	31	mg/L	-
17	Nitrate-Nitrogen	<1	4	1.2	mg/L	-
18	Total coliform	93	1100	>1100	MPN/100ML	

(Source: Alarm Ecological Laboratory)

Comparison Water Quality Measurement Using RT4 Near Station 5

- EC levels are around 0.5 mS/cm and DO ranges from 4.2 to 4.65 mg/L.
- The chlorophyll-A levels range from 5.9to 7.9 µg/L and the cyanobacteria levels range from 3to 4.4 µg/L.

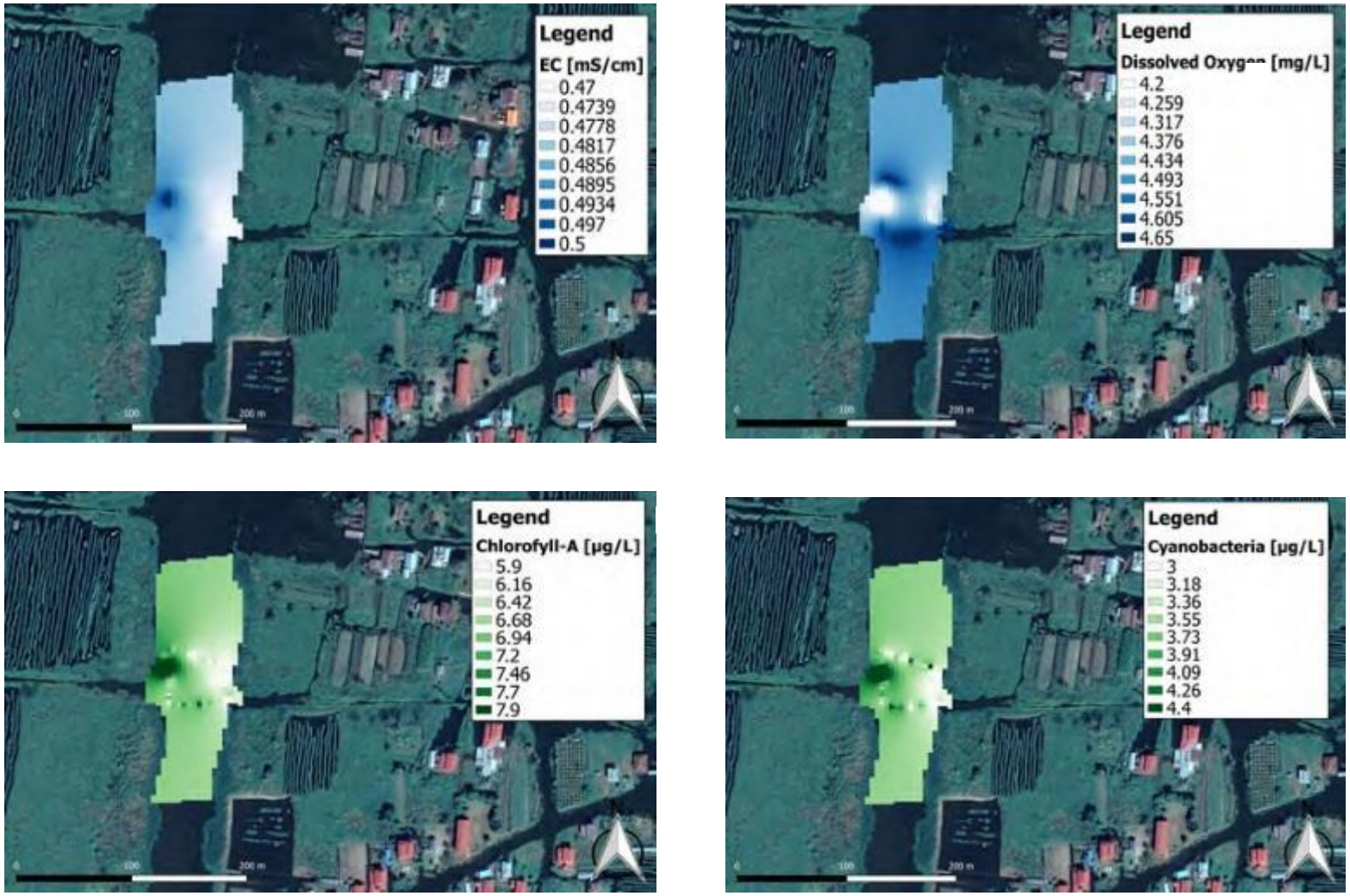


Fig. WQM at station 5 (source :Measuring lake water quality using drones, R.T. de Lange the Delft University of Technology)

Station 6

- Location – Near Ywa Ma Village
- Reason – Gold /silver smiths , Water Pollution, Crowded Population
- (Group of villages-13
- No of Housings-about 818,
- population –about 3115nos)

Fig. Environment of station 6

Table. Water Testing Result for Staton-6

Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standard
1	Temperature	20.833	19	30	‘C	
2	pH	7.7	7.57	7.26	S.U	6.5-8.5
3	Color	124	323	1160	HU	-
4	**Turbidity**	**24**	**130**	**132**	FAU	≤5
5	TDS	210	231	244	mg/L	≤500
6	TSS	26	76	129	mg/L	-
7	Total Solids	236	309	379	mg/L	-
8	**Conductivity**	**0.4**	**0.353**	**0.4**	mS/cm	≤2.5
9	**Hardness**	**210**	**292**	**200**	mg/L	≤500
10	Phosphorus	3.3	0.09	<0.02	mg/L	-
11	Arsenic	0	0.005	0	mg/L	≤0.01
12	**Manganese**	**0.5**	**0.26**	**4.5**	mg/L	≤0.4
13	Alkalinity	196	350	610	mg/L	-
14	Dissolved Oxygen	8	7.6	7.4	mg/L	-
15	BOD	3.2	4.5	7.5	mg/L	-
16	COD	<30	<30	32	mg/L	-
17	Nitrate-Nitrogen	<1	8	1.2	mg/L	-
18	Total Coliform	>1100	>1100	>1100	MPN/100ML	

(Source: Alarm Ecological Laboratory)

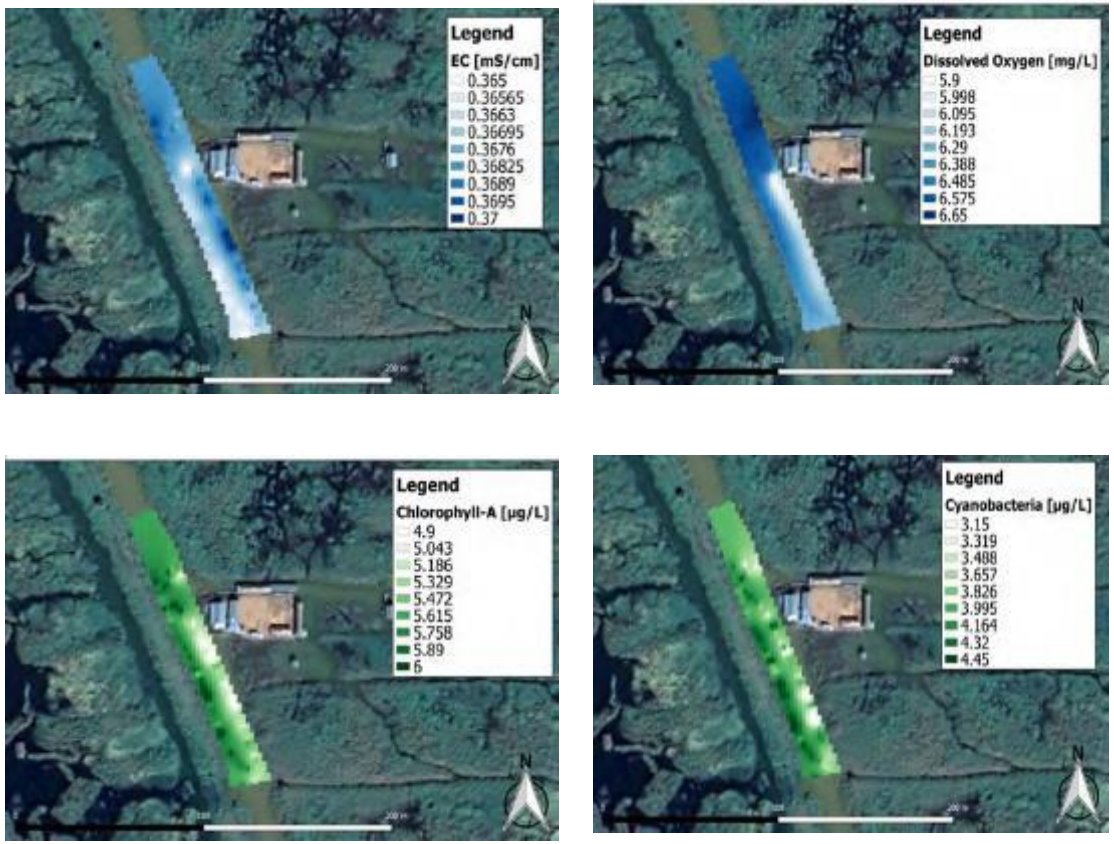


Fig. water quality results using RT4 at station (6)

- The EC levels only vary by 0.005 mS/cm and the DO levels only by 0.6 mg/L.
- The Clorphyll-A and Cyanobacteria levels are also quite normal.

Station 7

- Location – outflow of Kela village (in front of Sofitel hotel &Nyaung won village)
- Reason - Floating Garden, Agricultural Village, Crowded Population, Water Pollution
- (Group of villages-6
- No of Housings-about 1060,
- population –about 5169nos)

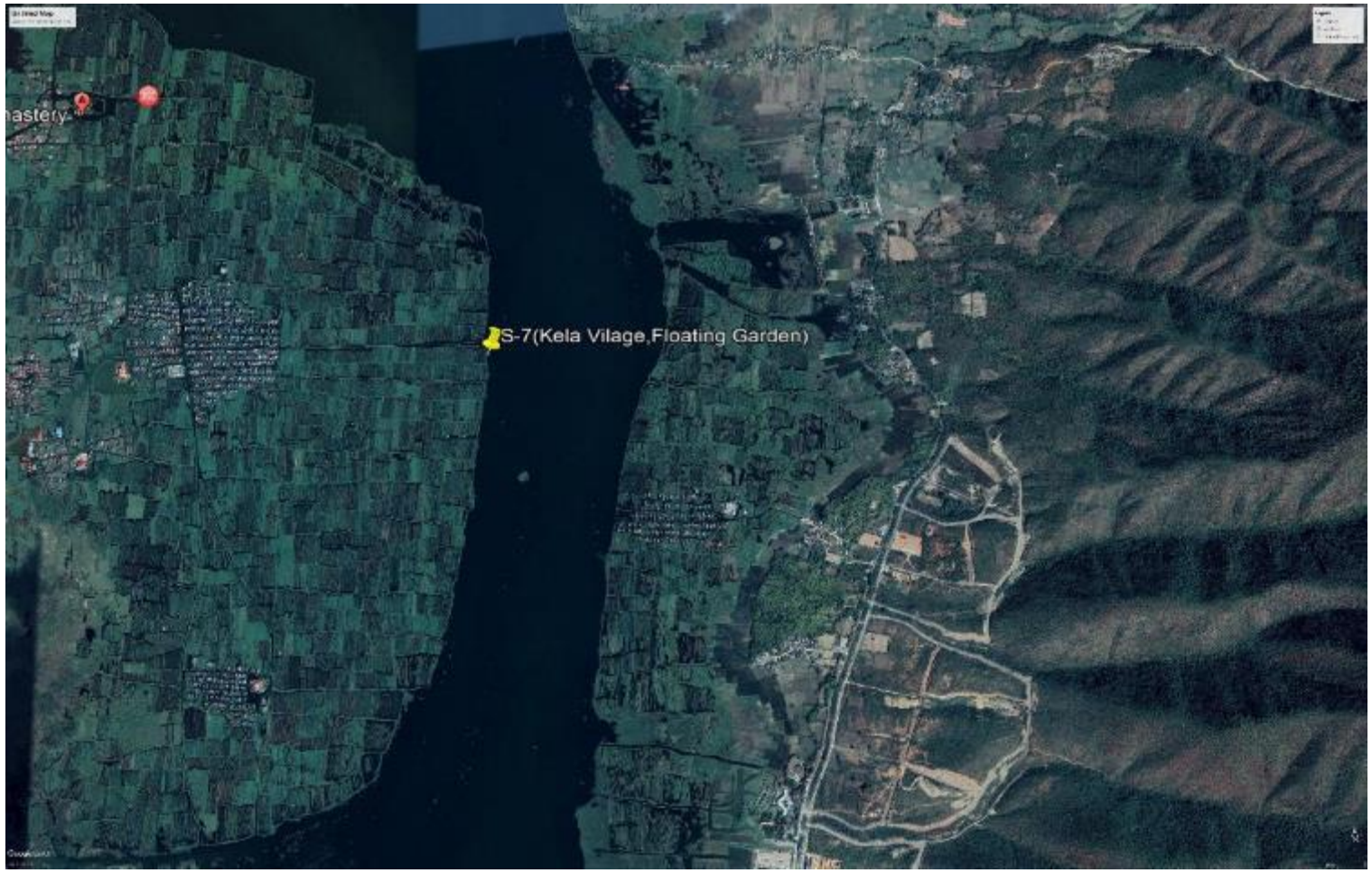


Fig. Environment of station 7

Table. Water Testing Result for Staton-7

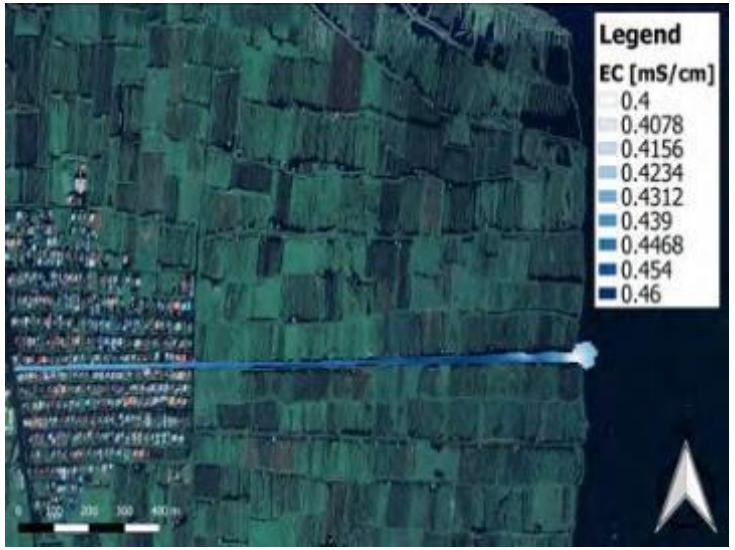
Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standards
1	Tem	27.5	22	29.5		
2	pH	7.6	7.32	7	S.U	6.5-8.5
3	Color	5	5	5	HU	-
4	Turbidity	<5	2	<5	FAU	≤5
5	TDS	228	248	245	mg/L	≤500
6	TSS	0	0	0	mg/L	-
7	Total Solids	228	224	241	mg/L	-
8	**Conductivity**	**0.4**	**0.342**	**0.37**	mS/cm	≤2.5
9	**Hardness**	**230**	**248**	**220**	mg/L	≤500
10	Phosphorus	6.6	0.17	<0.02	mg/L	-
11	Arsenic	0.005	0	0	mg/L	≤0.01
12	**Manganese**	**0.21**	**0.03**	**023**	mg/L	≤0.05
13	Alkalinity	206	330	160	mg/L	-
14	Dissolved Oxygen	7.2	5.6	5.6	mg/L	-
15	BOD	3.6	4.2	4.3	mg/L	-
16	COD	<30	<30	<30	mg/L	-
17	Nitrate-Nitrogen	<1	4	<0.02	mg/L	-
18	Total Coliform	93	>1100	210	MPN/100ML	

(Source: Alarm Ecological Laboratory)

Fig. WQM at Inle lake

Comparison Water Quality Measurement Using RT4 Near Station (7)

- This station runs from a village in the west, through floating gardens in the middle to open lake in the east.
- At the villages and the floating gardens, the DO levels are around 1 to 1.5 mg/L. When the boat arrives at the open water in the lake, the DO levels start rising again.
- The EC values are at average of the whole area in the east in the village, but go up when measuring between the floating gardens.



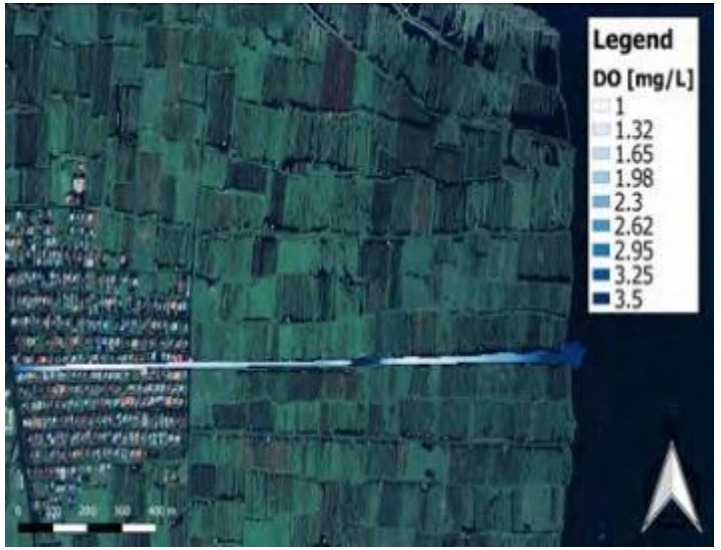


Fig. WQM at station 7 (source :Measuring lake water quality using drones, R.T. de Lange the Delft University of Technology)

Station 8

- Location – Inn Paw Kone (W)
- Reason - Weaving, Crowded Population
- (Group of villages-13
- Housing-about 936
- Population no-about4720nos)

Fig. Environment of station 8

Table. Water Testing Result for Station-8

Nos.	Quality Parameters	Water Test Result(Dec)	Water Test Result(Feb)	Water Test Result(March)	Units	Drinking Standards
1	Temperature	23.323	21	25.5	'C	
2	pH	7.5	7.53	7.2	S.U	6.5-8.5
3	Color	48	84	125	HU	-
4	**Turbidity**	**10**	**37**	**35**	FAU	≤5
5	TDS	212	260	243	mg/L	≤500
6	TSS	0.4	21	37	mg/L	-
7	Total Solids	220	239	245	mg/L	-
8	Conductivity	0.4	0.335	0.368	mS/cm	≤2.5
9	**Hardness**	**210**	**232**	**160**	mg/L	≤500
10	Phosphorus	4.7	0.15	<0.02	mg/L	-
11	Arsenic	0.05	0	0	mg/L	≤0.01
12	Manganese	<0.2	0.07	0.17	mg/L	≤0.4
13	Alkalinity	202	300	177	mg/L	-
14	Dissolved Oxygen	6.6	6.4	6.28	mg/L	-
15	BOD	3.3	4.3	4.8	mg/L	-
16	COD	<30	<30	<30	mg/L	-
17	Nitrate-Nitrogen	<1	<2	0.7	mg/L	-
18	Total Coliform	23	240	>1100	MPN/100ML	

(Source: Alarm Ecological Laboratory)

Main Stream Stations flowing into Inle lake

- Including small streams, there are 29 streams flowing totally as inflow channels in Inle lake catchment area.(17 streams from the eastern side ,11 streams from western side and one major stream from the northern side flowing into the lake.)
- There are 4 main streams stations to measure water quality in this study.

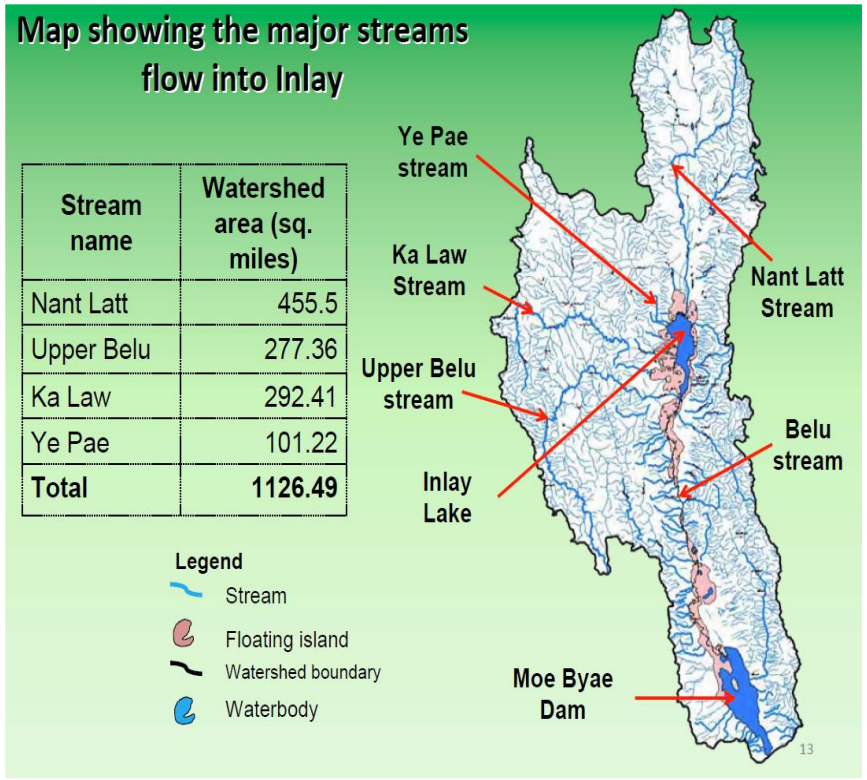


Fig of study area of Inle basin
(Source: MOECAF2014)

Table of Main Stream Stations flowing into Inle lake

No	Name	Location	Latitude (N)	Longitude (E)
1	Station A	Indein Weir (upper belu stream)	20.46016189N	96.84030932E
2	Station B	Kalaw stream	20.54382898 N	96.84029561E
3	Station C	Yay Pel Stream	20.69855346N	96.84029561E
4	Station D	Nant latt Stream	20.72122658 N	96.92226706 E

STATION-A

- Location – Indein Weir
- Reason - Inflow of Inle Lake(upper belu stream)
- (Latitude – 20.46016189N
- Longitude – 96.84030932E)
- Elevation-854m

Fig . Environment of Intein Stream and water quality measurement

Table. Water Testing Result for Station-A

Nos.	Quality Parameters	Water Sample Result(Feb)	Water Sample Result(March)	Units	Drinking Standards
1	Temperature	19	22.21	’C	
2	pH	7.73	7.55	S.U	6.5-8.5[b]
3	Color	0	0	HU	-
4	Turbidity	3	<5	FAU	≤5[b]
5	TDS	250	268	mg/L	≤500[b]
6	TSS	1	0	mg/L	-
7	Total Solids	227	229	mg/L	-
8	Conductivity	0.414	0.4	mS/cm	≤2.5[b]
9	Hardness	264	210	mg/L	≤500[c]
10	Phosphorus	0.033	0.02	mg/L	-
11	Arsenic	0	0	mg/L	≤0.01[a]
12	Manganese	<0.01	<0.01	mg/L	≤0.4[c]
13	Alkalinity	200	350	mg/L	-
14	Dissolved Oxygen	8.1	8	mg/L	-
15	BOD	3.4	3.3	mg/L	-
16	COD	<30	<30	mg/L	-
17	Nitrate-Nitrogen	2.6	2.4	mg/L	-

(Source: Alarm Ecological Laboratory

STATION-B

- Location – Kalaw stream
- Reason - Inflow of Inle Lake
- (Latitude –20.54382898 N
- Longitude – 96.84029561E)
- Elevation-849m

Fig . Environment of Kalaw Stream and water quality measurement

Table. Water Testing Result for Station-B

Nos.	Quality Parameters	Water Sample Result(Feb)	Water Sample Result(March)	Units	Drinking Standards
1	Temperature	23	24.7	'C	
2	pH	7.35	7.28	S.U	6.5-8.5[b]
3	Color	40	73	HU	-
4	**Turbidity**	**31**	**10**	FAU	≤5[b]
5	TDS	339	363	mg/L	≤500[b]
6	TSS	12	13	mg/L	-
7	Total Solids	287	301	mg/L	-
8	Conductivity	**0.531**	**0.55**	mS/cm	≤2.5[b]
9	Hardness	329	280	mg/L	≤500[c]
10	Phosphorus	<0.02	<0.02	mg/L	-
11	Arsenic	0	0	mg/L	≤0.01[a]
12	Manganese	0.07	0.22	mg/L	≤0.4[c]
13	Alkalinity	290	320	mg/L	-
14	Dissolved Oxygen	8.4	8.2	mg/L	-
15	BOD	<3	3.2	mg/L	-
16	COD	<30	<30	mg/L	-
17	Nitrate-Nitrogen	0.8	1.1	mg/L	-

(Source: Alarm Ecological Laboratory)

STATION-C

- Location – Yay Pel Stream
- Reason - Inflow of Inle Lake
- Latitude – 20.69855346N
- Longitude – 96.84029561E
- Elevation-868m

Fig . Environment of Yay Pel Stream

Table. Water Testing Result for Station-C

Nos.	Quality Parameters	Water Sample Result(Feb)	Water Sample Result(March)	Units	Drinking Standards
1	Temperature	19	23.5	'C	
2	pH	7.7	7.63	S.U	6.5-8.5[b]
3	Color	22	14	HU	-
4	Turbidity	18	<5	FAU	≤5[b]
5	TDS	272	233	mg/L	≤500[b]
6	TSS	4	3	mg/L	-
7	Total Solids	242	234	mg/L	-
8	Conductivity	0.442	0.39	mS/cm	≤2.5[b]
9	Hardness	328	291	mg/L	≤500[c]
10	Phosphorus	0.0429	0.02	mg/L	-
11	**Arsenic**	0.025	0	mg/L	≤0.01[a]
12	Manganese	<0.01	0.03	mg/L	≤0.4[c]
13	Alkalinity	340	310	mg/L	-
14	Dissolved Oxygen	8.3	8.3	mg/L	-
15	BOD	3.2	3.6	mg/L	-
16	COD	<30	<30	mg/L	-
17	Nitrate-Nitrogen	<0.5	1.9	mg/L	-

(Source: Alarm Ecological Laboratory

STATION-D

- Location – Nant latt Stream
- Reason - Inflow of Inle Lake
- Latitude –20.72122658 N
- Longitude –96.92226706 E
- Elevation-845m

Fig . Environment of Nant Latt Stream

Table. Water Testing Result for Station-D

Nos.	Quality Parameters	Water Sample Result(Feb)	Water Sample Result(March)	Units	Drinking Standards
1	Temperature	21	25.2	'C	
2	pH	7.2	7.13	S.U	6.5-8.5[b]
3	Color	31	25	HU	-
4	Turbidity	**24**	5	FAU	≤5[b]
5	TDS	326	324	mg/L	≤500[b]
6	TSS	7	6	mg/L	-
7	Total Solids	302	281	mg/L	-
8	Conductivity	0.575	0.5	mS/cm	≤2.5[b]
9	Hardness	278	260	mg/L	≤500[c]
10	Phosphorus	0.3069	0.02	mg/L	-
11	Arsenic	0	0	mg/L	≤0.01[a]
12	Manganese	<0.01	0.04	mg/L	≤0.4[c]
13	Alkalinity	430	320	mg/L	-
14	Dissolved Oxygen	9.6	8.9	mg/L	-
15	BOD	<3	3.1	mg/L	-
16	COD	<30	<30	mg/L	-
17	Nitrate-Nitrogen	0.6	2	mg/L	-

(Source: Alarm Ecological Laboratory

Comparison Water Parameter Results of stations

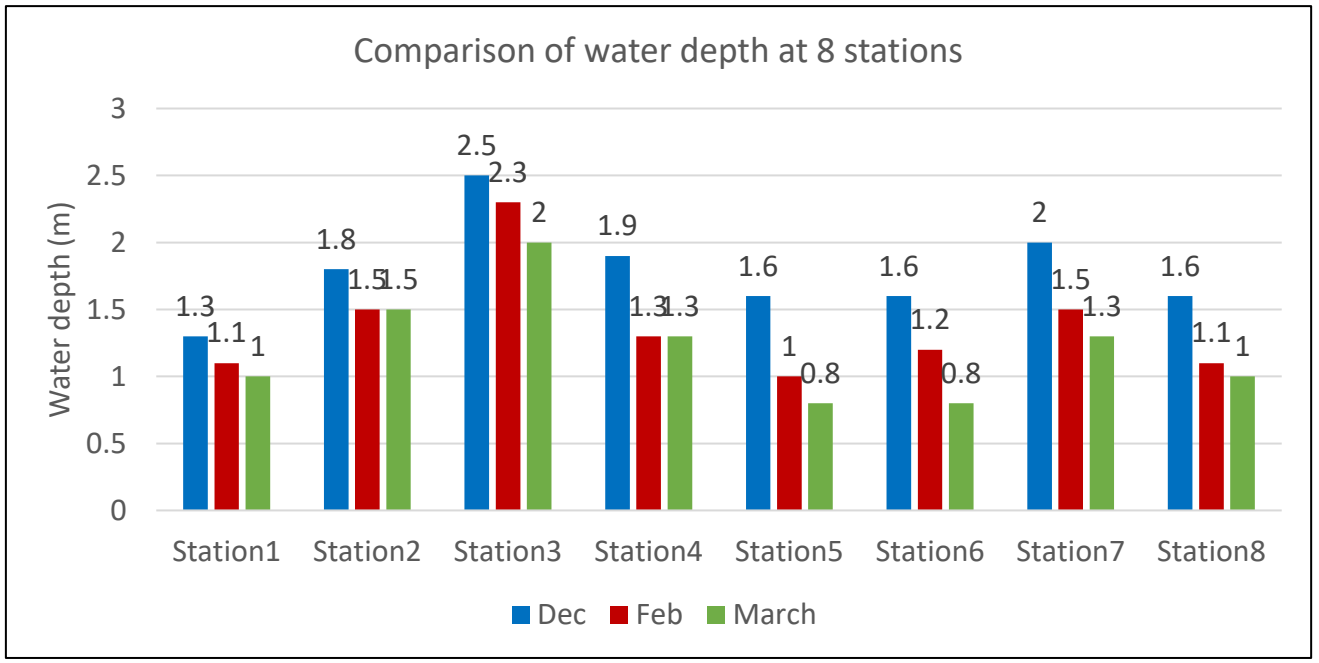


Fig Comparison results of temperature for 12 stations

- Water depths in Inle lake decrease within Dec to March.
- (Range 1.3to 2.5m(dec)
- Range 1 to2.3(feb)
- Range 0.8 to 2(march)
- <u>Overall average 1to2.5m)</u>

Fig .Paungdaw Ou Pagoda at Inle lake ,April2020
(source:facebook)

Comparison Water Parameter Results of stations (continue-)

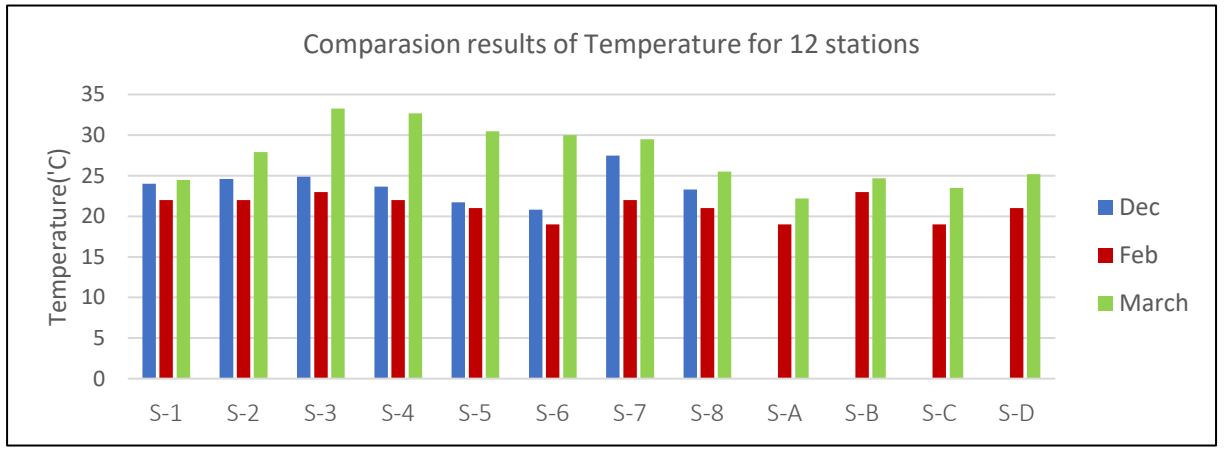


Figure. Comparison results of temperature for 12 stations

- The study area has a humid subtropical highland climate and lake water temperature ranges 19-33 ˚C.
- The value of pH in water samples of all station is over 7.
- Hardness of Inle lake is high because it is a part of Shan Plateau which has main limestone formation. (It ranges from 140 ton363 mg/l. Alkalinity ranges from 185 to 840mg/l.)

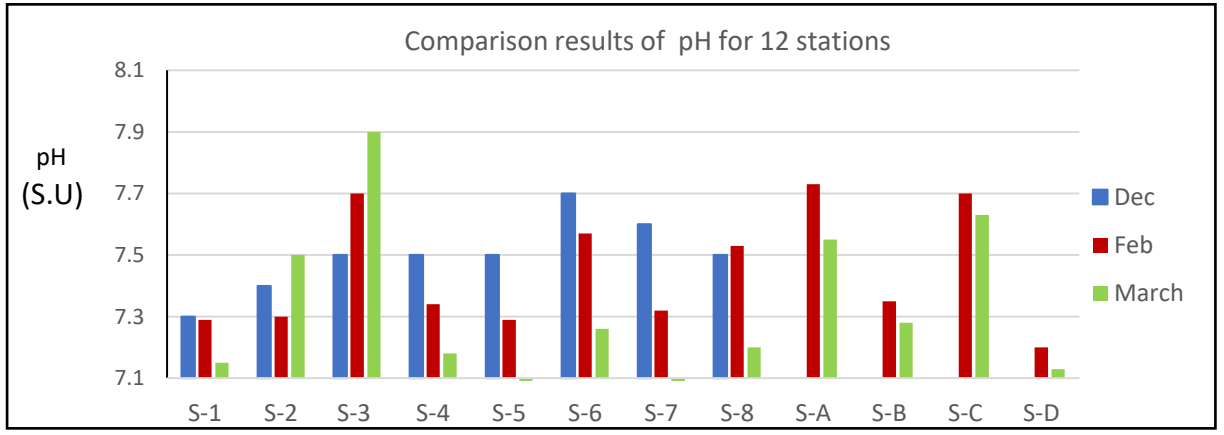


Figure. Comparison results of pH for 12 stations

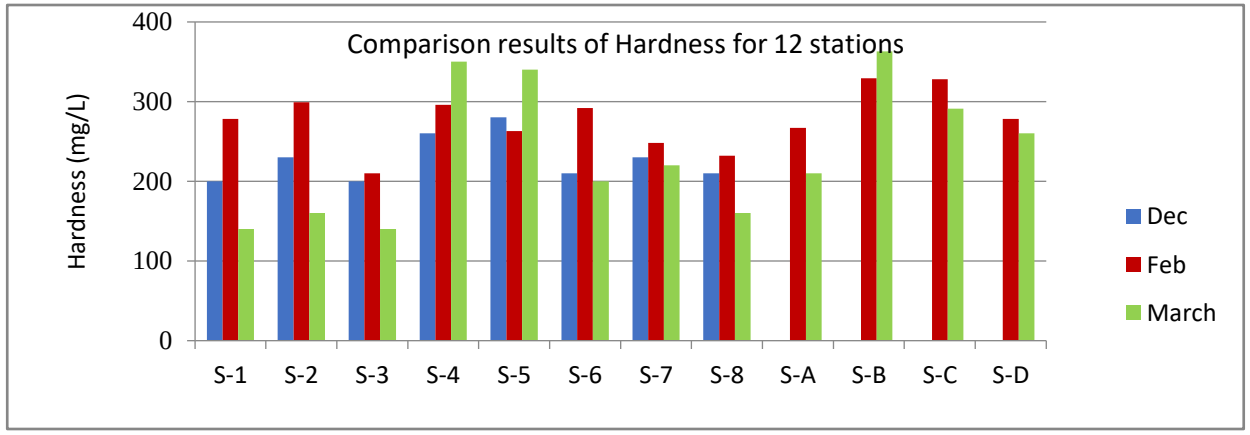


Figure. Comparison results of hardness for 12 stations

Comparison Water Parameter Results of stations (continue-)

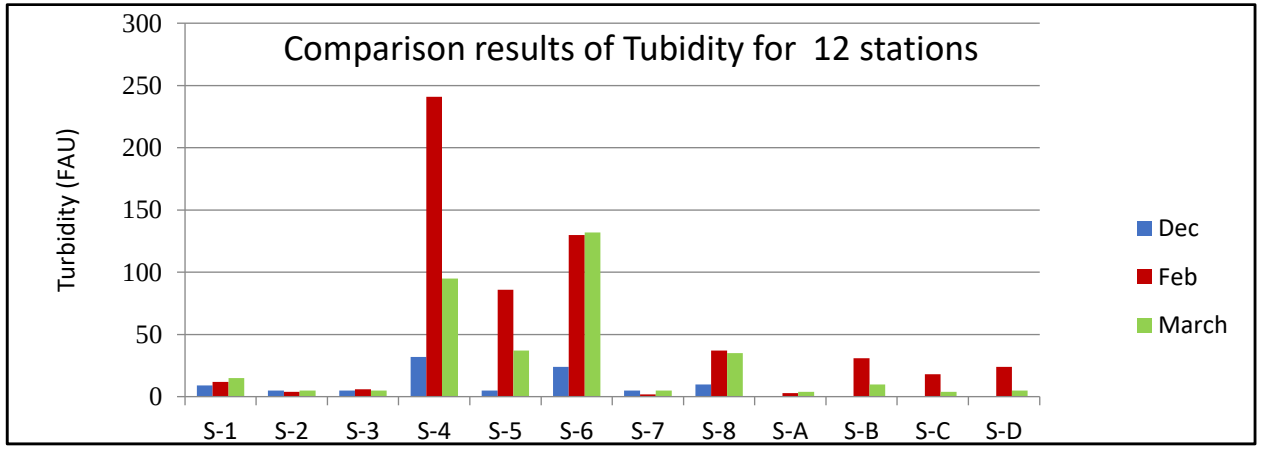


Fig. Comparison results of turbidity for 12 stations

Fig. Low water level depth in villages (dry season)

- The result of turbidity values ranges from 5 to 241FAU.
- Thus, most of the result are higher than the permissible limit expect station 2,3,7 and A.

- Water colour of the lake is noticeable different because of water depth and sedimentation.
- Colour ranges from 5to 1160 HU in lake and from 0 to 73HU at streams.

Fig. Different water colour in lake and villages

Comparison Water Parameter Results of stations (continue-)

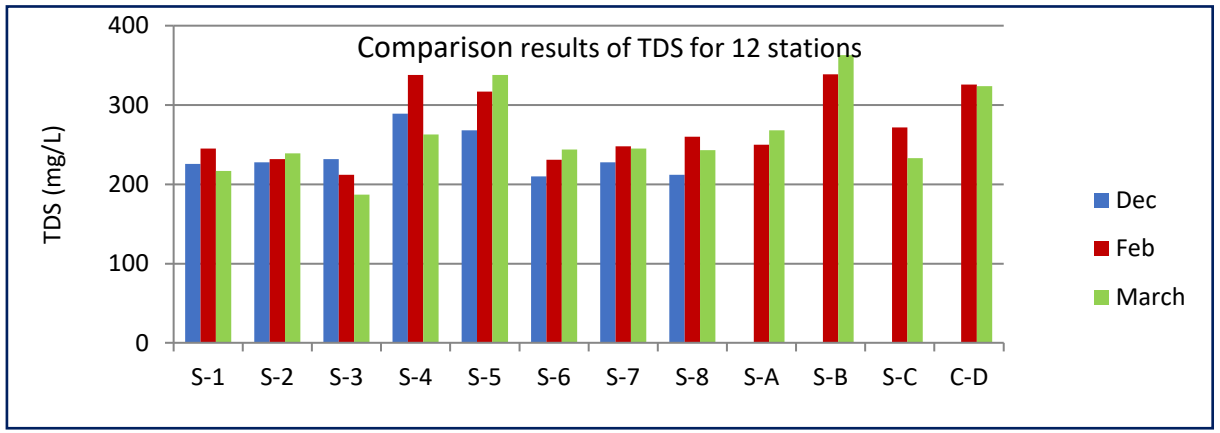


Figure. Comparison results of TDS for 12 stations

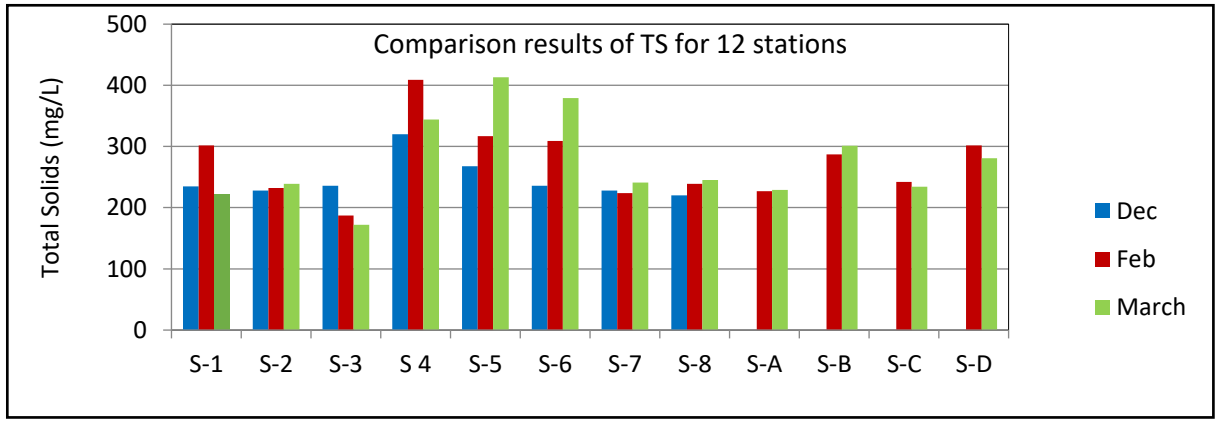


Figure. Comparison results of TS for 12 stations

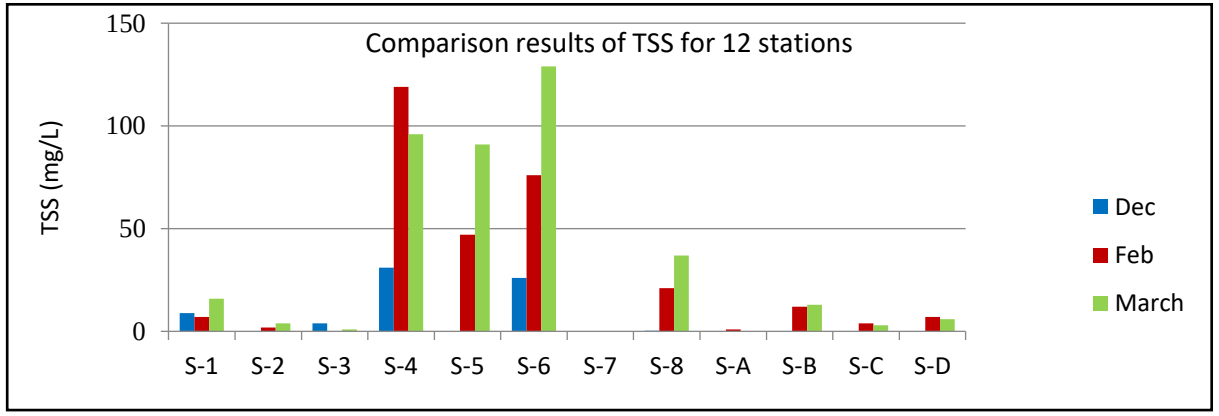


Figure. Comparison results of TSS for 12 stations

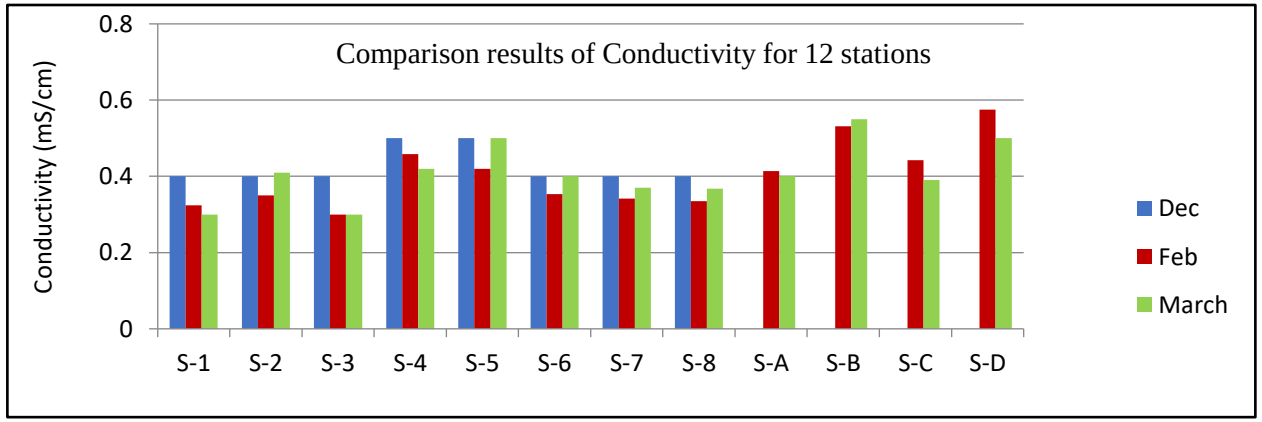


Figure. Comparison results of conductivity for 12 stations

- Result of TDS in all stations are lower than the standard limit.
- TSS ranges from 0 to 129 m/l and TS ranges from 172 to 409 mg/l.
- EC ranges from 0.3 to 0.5 mS/cm at 12 stations

Comparison Water Parameter Results of stations (continue-)

- DO ranges 5 to 7.6 mg/l in lake and from 8 to 9.6 mg/l in streams.
- COD is less than 30mg/l but station 4 is 39mg/l at second time; station 5 is 31 mg/l and station 6 is 32 at third time.
- Most of BOD results from 3 to 7.5mg/L.

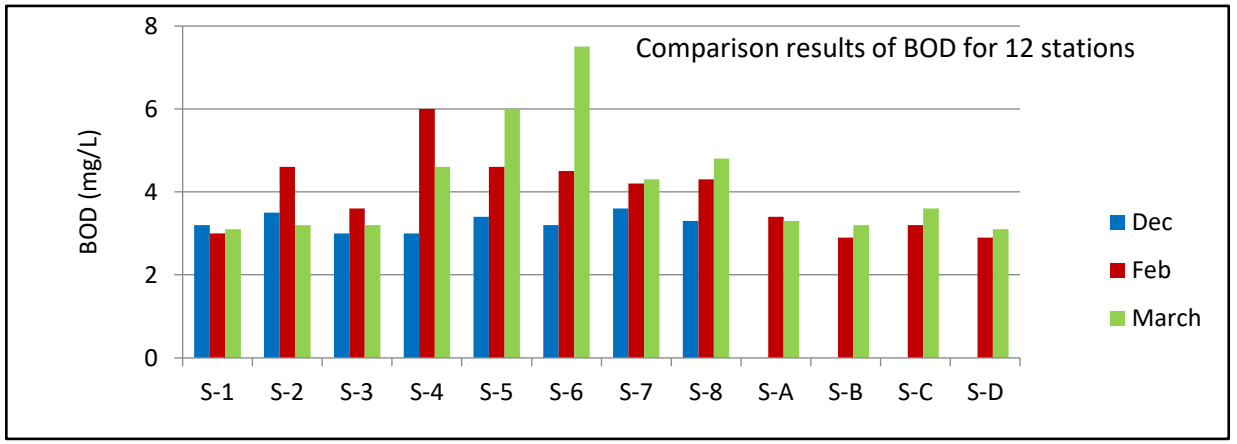


Fig. Comparison results of BOD for 12 stations

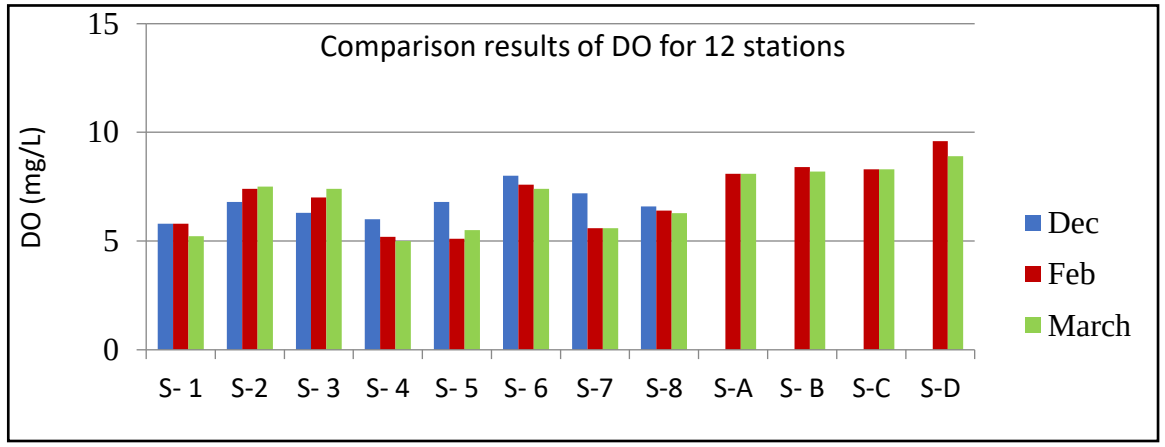


Fig. Comparison results of DO for 12 stations



Fig. Domestic waste ,sanitary system and solid waste system of some villages




Fig. Chemical waste from weaving discharged directly to the lake and land

Discussion and Conclusion

- The study area is one of the most valuable existences in Myanmar and it is therefore important to monitor and manage the water quality.
- From field surveys and water quality results, the levels of arsenic, manganese and phosphorus were above the permissible limit at some stations.
- According to the water level measuring records, the water depths of the lake are lowering over time and it increases the turbidity of the water. This raises the main point to consider the question on how to control sedimentation in the lake.
- Another observation is that most villages had sanitary waste water systems (bio-tech), but some villages had poor sanitary waste water systems. At the most stations in lake, total coliform count was found more than 1100 MPN/100 mL.
- The immediate attention should also be paid on the problems of the construction and management of floating gardens if the open lake area and water quality are to be preserved .
- Due to many factors the water quality of Inle Lake is changing and it should be checked seasonally and spatially.
- Concluding, the continuous monitoring of the Inle Lake is required in the district to protect the water quality in the future from any possible contamination due to population growth, increasing industrialization and agricultural practices, etc.
- Water quality of Inle lake are one of the primary issues to be considered in the long-term integrated water management system for the Inle basin.

Thank you for your kind attention

References

Aung, P. P., Mao, Y., Hu, T., Qi, S., Tian, Q., Chen, Z., & Xing, X. (2019). Metal concentrations and pollution assessment in bottom sediments from Inle Lake, Myanmar. *Journal of Geochemical Exploration*, *207*(October 2018), 106357. https://doi.org/10.1016/j.gexplo.2019.106357

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z.-I., Knowler, D. J., Lévêque, C., Naiman, R. J., Prieur-Richard, A.-H., Soto, D., Stiassny, M. L. J., & Sullivan, C. A. (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews*, *81*(02), 163. https://doi.org/10.1017/S1464793105006950

Eckstein, D., Künzel, V., & Schäfer, L. (2021). *GLOBAL CLIMATE RISK INDEX 2021*. www.germanwatch.org

Furuichi, T., & Wasson, R. J. (2011). Placing sediment budgets in the socio-economic context for management of sedimentation in Lake Inle, Myanmar. *IAHS-AISH Publication*, *349*(June 2016), 103–113.

Kattelus, M., Rahaman, M. M., & Varis, O. (2014). Myanmar under reform: Emerging pressures on water, energy and food security. *Natural Resources Forum*, *38*(2), 85–98. https://doi.org/10.1111/1477-8947.12032

May, S. Y. (2007). *Changes of water quality and water surface area in Inle Lake Myanmar*.

Michalon, M., Gunnell, Y., Lejot, J., Mialhe, F., & Aung, T. (2019). Accelerated degradation of Lake Inle (Myanmar): A baseline study for environmentalists and developers. *Land Degradation and Development*, *30*(8), 928–941. https://doi.org/10.1002/ldr.3279

Oki, T., & Kanae, S. (2006). Global hydrological cycles and world water resources. *Science*, *313*(5790), 1068–1072. https://doi.org/10.1126/science.1128845

Re, V., Thin, M. M., Setti, M., Comizzoli, S., & Sacchi, E. (2018). Present status and future criticalities evidenced by an integrated assessment of water resources quality at catchment scale: The case of Inle Lake (Southern Shan state, Myanmar). *Applied Geochemistry*, *92*(August 2017), 82–93. https://doi.org/10.1016/j.apgeochem.2018.03.005

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J., Kidd, K. A., MacCormack, T. J., Olden, J. D., Ormerod, S. J., Smol, J. P., Taylor, W. W., Tockner, K., Vermaire, J. C., Dudgeon, D., & Cooke, S. J. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews*, *94*(3), 849–873. https://doi.org/10.1111/brv.12480

Sidle, R. C., Ziegler, A. D., & Vogler, J. B. (2007). Contemporary changes in open water surface area of Lake Inle, Myanmar. *Sustainability Science*, *2*(1), 55–65. https://doi.org/10.1007/s11625-006-0020-7

Swe, T. (2013). *Assessment of Water Quality of Inlay Lake*.

Taft, L., & Evers, M. (2016). A review of current and possible future human-water dynamics in Myanmar's river basins. *Hydrology and Earth System Sciences*, *20*(12), 4913–4928. https://doi.org/10.5194/hess-20-4913-2016

Thin, M. M., Setti, M., Sacchi, E., Re, V., Riccardi, M. P., & Allais, E. (2020). Mineralogical and geochemical characterisation of alkaline lake sediments to trace origin, depositional processes, and anthropogenic impacts: Inle Lake (Southern Shan State, Myanmar). *Environmental Earth Sciences*, *79*(8), 1–18. https://doi.org/10.1007/s12665-020-08909-4

Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S. E., Sullivan, C. A., Liermann, C. R., & Davies, P. M. (2010). Global threats to human water security and river biodiversity. *Nature*, *467*(7315), 555–561. https://doi.org/10.1038/nature09440

Laboratory Testing Methods(Alarm Ecological Laboratory)		
Index	Instruments/Method	References/Descriptions
1	pH Meter	Electrode Method (Approved by EPA, ISO, ASTM), Hanna electrode Meter Certified by 2014 EMS, certified by QMS
2	DQ Meter	Electrochemical probe method, Dissolved Oxygen Measurement(Approved by EPA, ISO, ASTM), Horiba DO electrode certified with IP67 standards and measures
3	SpectroDirect Methods	Lovibond brand reagent testing methods, precision of the methods are identical to the precision specified in the standard literature AWWA and ISO
4	TDS Meter	Electrode Method (Approved by EPA, ISO, ASTM), Hanna electrode Meter Certified by 2014 EMS, certified by QMS
5	Conductivity Meter	Electrode method, conductivity cell (Approved by EPA, ISO, ASTM), Hanna electrode Meter Certified by 2014 EMS, certified by QMS
6	BOD Testing Method	Method 405.1 USEPA Method for Chemical Analysis of Water and Wastewater
7	Atomic Absorption Spectrophotometer	Shimadzu AA-6200, which is based on Japan Water Standard Testing Method also approved by EPA and ASTM
8	Arsenic Test Kit	Lovibond brand Arsenic Test kit certified by DIN ISO 1997/ Follow Procedure: Meets WHO requirements:

Standards References		
Index	Standard Names	References
a	WHO Standard for Drinking Water (2011)	Guidelines for Drinking Water Quality 4th Edition, World Health Organization 2011.
b	US EPA Drinking Water Standard 2018	2018 Edition of the Drinking Water Standards and Health Advisories, EPA 822-F-18-001, Office of Water, USEPA, Washington DC, March 2018
c	Available Myanmar Drinking Water Standard	Proposed National Drinking Water Standards, Ministry of Health, September 2014
d	Myanmar Emission Guideline (2015)	National Environmental Quality (Emission) Guidelines, Order No. (61/2015) MOECAF, 2015 December 29
*	At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptor and assimilative capacity; when the zone is not defined, use 100 meters from the point of discharge	