ASSESSMENT OF DIURNAL FLUCTUATION OF WATER QUALITY PARAMETERS IN DIFFERENT TYPE OF PONDS IN RUPANDEHI DISTRICT, NEPAL

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Background

- ❑ Aquaculture has been growing as a potential source of income among farmers of Southern Nepal (FAO, 2021).
- ❑ The status of various water quality parameters like temperature, pH and oxygen is not the same within and between ponds at different time, season, location, stocking density and with different management practices (Khanom et. al, 2014).

Statement of the problem

- ❑ Problems faced by Nepalese aquaculture system
  - ○ Lack skill for proper pond management (Preliminary field visit)
  - ○ High and sudden fish mortality (PMAMP, Rupandehi)
  - ○ Sedimentation and water quality deterioration (FAO, 2021)
- ❑ Alteration of physical and chemical properties of water beyond tolerance limit creates stress, reduces survival rate of fish and decrease production, profit and product quality (Boyd, 1984).

Objective

To assess the diurnal fluctuation of water quality parameters in different culture media during summer days in Fish farming areas of Rupandehi district

Experimental details

Baidauli Tole of Siyari Municipality
Rupandehi District, Nepal

Subjects: 18 Ponds

Between Subject Factor
- Pond Type
  - ❖Earthen Production Pond (EPP) - 6
  - ❖Earthen Nursery Pond (ENP) - 6
  - ❖Plastic Production Pond (PPP) - 6

Within Subject Factor
- Time of day
  - ❖T1 – Dawn (6:00 AM)
  - ❖T2 – Noon (12 PM)
  - ❖T3 – Dusk (6:00 PM)
  - ❖T4 – Night (2:00 AM)

Repeated Observations for 10 times (5 cloudy days, 5 sunny days) during 3 months (March, April, May)

Figure 1: Treatment details for the assessment of diurnal fluctuation of water quality at Siyari Nepal, 2021

Pond Characteristics

- ❑ Water source: (Boring water)
- ❑ Area of pond: (5±0.5 kattha)
- ❑ Water depth 1.5 m (regularly monitored to maintain constant)
- ❑ Liming: 5kg per 100 sq.m. area
- ❑ Stocking rate: production ponds - 300 fish/katha; nursery ponds 500 fingerlings/katha
- ❑ Feed: Rice bran and mustard oil cake, major ingredient of home made feed, mixed in equal ratio to make balls and sun dried
- ❑ Daily feeding rate: 5% of body weight of fish

Data and data types

- ❑ Field determination of physical (temperature and total dissolved solid) and chemical (pH, dissolved oxygen, salinity, electrical conductivity and oxygen reduction potential) properties of water of ponds was carried out by using the device 'Aquaread'.
- ❑ Variables were measured at a depth of 15 cm (epilimnion) at the same relative location (opposite side of the water inlet region) in each pond.

Data analysis techniques

- ❑ Mean values were computed and compared with acceptable range of values suggested by Nepal Water Quality Guidelines for Aquaculture (CBS, 2019)
- ❑ Diurnal variation of each parameter were analyzed differently through graphical representation.
- ❑ Variation in each parameter at different sampling hours in all 3 type of ponds were compared using linear Mixed Effect Model from Lme4 package in R-studio for unstructured residual variance covariance matrix, as recommended by (Ozenne, 2018) and presented as Repeated Measures ANOVA.
- ❑ The significance for main and interaction effect was further interpreted by simultaneous test for general hypothesis using multiple comparison of means: Tukey contrasts.

- ❑ Variables showing strong and significant correlation were subjected to linear regression to obtain equation for each day.
- ❑ Values of dependent variables for other observations were predicted, based on the equations with higher coefficient of determination, to obtain Mean Absolute Percentage Error (MAPE) as also conducted by Xu and Boyd (2016).

$$MAPE = \frac{100}{n}\sum_{t=1}^{n}\frac{(A-P)}{A}$$

n = Number of observation
A = Actual Value, P = Predicted Value

Data overview

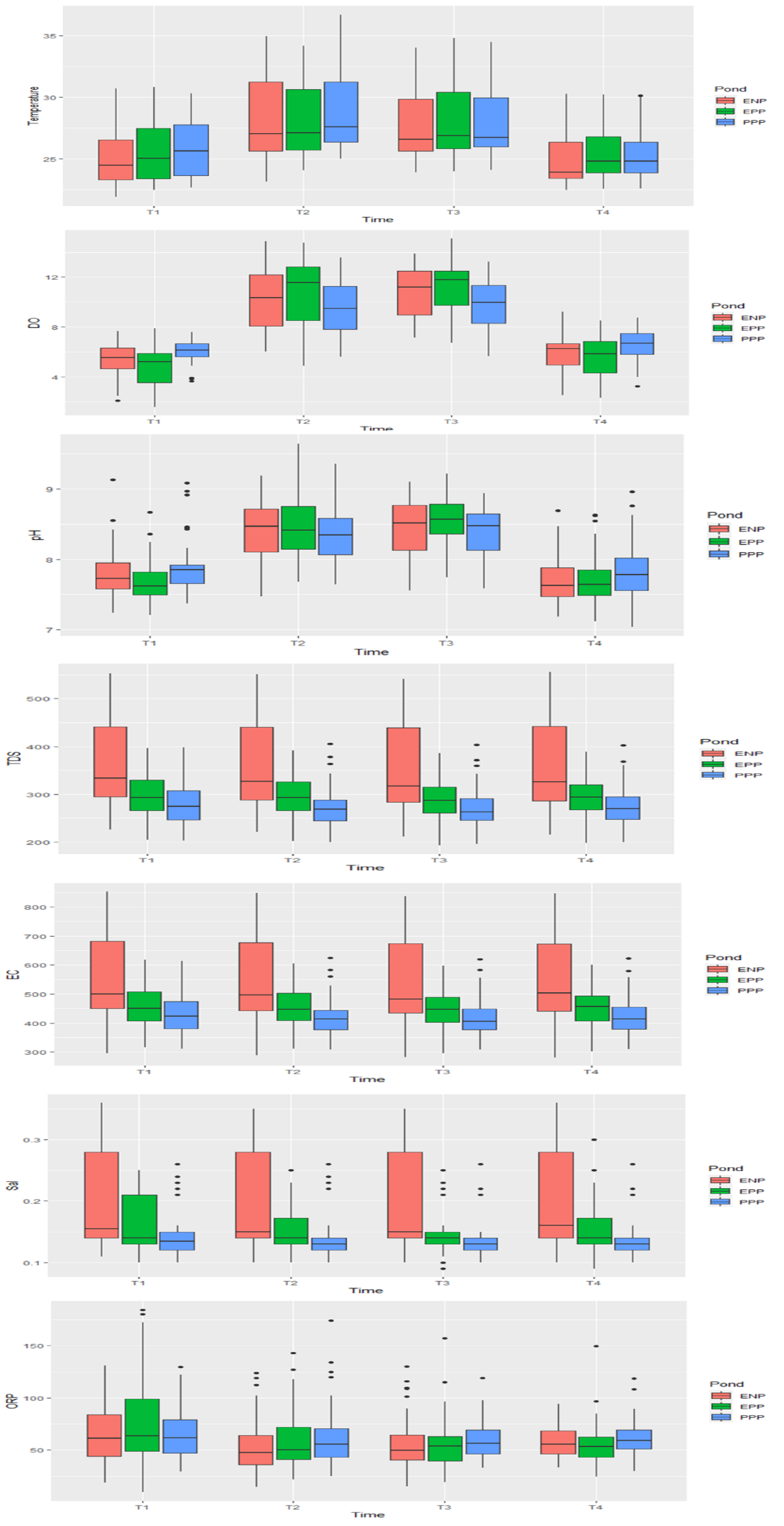

Figure 2: Boxplot for water quality parameters vs. time of day for sampled ponds at Siyari Nepal, 2021

3-way Repeated Measures ANOVA

Table 1: Repeated measures ANOVA table for water quality parameters of pond water at Siyari Nepal, 2021

Source of interaction	Temp	DO	pH	TDS	EC	Sal	ORP
Intercept	***	***	***	***	***	***	***
Time	***	***	***	**	***	**	***
Pond	ns	ns	ns	ns	ns	ns	ns
Day	***	**	**	ns	*	**	***
Time:Pond	ns	*	*	ns	.	*	ns
Time:Day	***	***	***	ns	.	.	***
Pond:Day	ns	ns	ns	ns	ns	ns	*
Time:Pond:Day	*	ns	ns	ns	ns	*	ns
Observation	720	720	720	720	720	720	720
[1]Conditional R^2	NA	0.913	0.872	0.976	0.981	0.96	0.73
[2]Marginal R^2	0.958	0.778	0.616	0.286	0.267	0.252	0.347
[3]Adjusted ICC	NA	0.606	0.668	0.966	0.974	0.947	0.587
[4]Conditional ICC		0.135	0.257	0.69	0.714	0.708	0.383

* - significant at 5%, ** - significant at 1%, *** - significant at 0.1%, ns – not significant

[1] R^2: Regression coefficient – obtained % variance was explained by the random effects (Subject) and fixed effects viz. Time, Pond and Day
[2] Marginal R^2 – obtained % variance was explained by fixed effects
[3] ICC: Intra-Class Correlation Coefficient – measurements in same group of fixed effects resemble each other with obtained strength
[4] Conditional ICC – measurements in same group for random and fixed effects resemble each other with obtained strength

Pairwise comparison: Time

Table 2: Pairwise comparison of water quality parameters for significant time factor at Siyari Nepal, 2021

Parameters	T1/T2	T1/T3	T1/T4	T2/T3	T2/T4	T3/T4
Temperature	4.473 ***	3.033 ***	0.891	-1.44 **	-3.581 ***	-2.141 ***
Dissolved Oxygen	5.158 ***	5.308 ***	0.64	0.15	-4.515 ***	-4.665 ***
pH	0.628 ***	0.617 ***	0.063	-0.011	-0.565 ***	-0.553 ***
Total Dissolved Solid	16.833	-7.833	-5.667	-24.667 **	-22.5 **	2.167
Electrical Conductivity	24.833 *	-10.333	-8.333	-35.167 ***	-33.667 **	1.5
Salinity	0.0183.	-0.0067	-0.005	-0.025 **	-0.0233 **	0.0017
Oxygen Reduction Potential	24.55	44.767 ***	33.617 **	20.217	9.067	-11.15

Note: * - significant at 5%, ** - significant at 1%, *** - significant at 0.1%
T1 – 6 AM, T2 – 12 Noon, T3 – 6 PM, T4 – 2 AM

Cloudy vs Sunny Day (T-test: Time)

Table 3: Mean comparison of water quality parameters between cloudy and sunny day for different time at Siyari Nepal, 2021

Parameters	T1	T2	T3	T4
Temperature	P<0.001	P<0.001	P<0.001	P<0.001
Dissolved Oxygen	P<0.001	P<0.001	P<0.001	P<0.001
pH	P>0.05	P<0.01	P>0.05	P<0.05
Total Dissolved Solid	P<0.001	P<0.01	P<0.01	P<0.01
Electrical Conductivity	P<0.001	P<0.01	P<0.01	P<0.01
Salinity	P<0.01	P<0.01	P<0.05	P<0.05
Oxygen Reduction Potential	P<0.01	P<0.05	P>0.05	P>0.05

Cloudy vs Sunny Day (T-test: Pond)

Table 4: Mean comparison of water quality parameters between cloudy and sunny day for different ponds at Siyari Nepal, 2021

Parameters	ENP	EPP	PPP
Temperature	P<0.001	P<0.001	P<0.001
Dissolved Oxygen	P<0.001	P<0.001	P<0.01
pH	P>0.05	P>0.05	P<0.01
Total Dissolved Solid	P<0.001	P<0.001	P<0.05
Electrical Conductivity	P<0.01	P<0.01	P<0.05
Salinity	P<0.001	P<0.001	P<0.05
Oxygen Reduction Potential	P>0.05	P>0.05	P>0.05

Regression (Cloudy day)

Table 5: Linear correlation, regression equations between different water quality parameters for cloudy days at Siyari, 2021

Day	Linear regression	Correlation coefficient	R^2 value	Equation (Y = a + bx)	MAPE
P2C3	Oxygen Reduction Potential against Dissolved Oxygen	-0.612***	0.374	Y = 91.943 -4.189x	36.31
P3C3	Dissolved Oxygen against Temperature	0.859***	0.738	Y = -240.908 + 0.828x	28.76
P3C5	Electric Conductivity against pH	-0.568**	0.322	Y = 1116.601 -82.786x	15.3
P1C1	Electric Conductivity against Total Dissolved Solid	0.927***	0.997	Y = -10.127 + 1.582x	1.76
P3C5	pH against Total Dissolved Solid	-0.558***	0.312	Y = 9.797 -0.006x	6.06
P1C1	pH against Temperature	0.758***	0.574	Y = -57.155 + 0.219x	5.86
P3C5	Oxygen Reduction Potential against pH	-0.56***	0.314	Y = 142.66 -10.90x	29.52

Note: ** - significant at 1%, *** - significant at 0.1%
MAPE value: <10 – Best prediction, 10-20 – Good prediction, 20-50 – Reasonable prediction (Lewis, 1942), P1 – ENP, P2 – EPP, P3 – PPP, Cn – nth Cloudy Day

Regression (Sunny day)

Table 6: Linear correlation, regression equations between different water quality parameters for sunny days at Siyari, 2021

	Linear regression	Correlation Coefficient	R^2 value	Equation (Y = a + bx)	MAPE
P2S4	Oxygen Reduction Potential against Dissolved Oxygen	-0.688***	0.474	Y = 86.439 -4.205x	28.38
P3S2	Electric Conductivity against pH	-0.591**	0.349	Y = 906.997 -60.977x	15.14
P2S4	Electric Conductivity against Total Dissolved Solid	0.937***	0.999	Y = -4.972 + 1.56x	1.46
P3S1	pH against Total Dissolved Solid	-0.568**	0.371	Y = 10.348 -0.008x	6.44
P2S4	pH against Temperature	0.886***	0.785	Y = -61.982 + 0.231x	10.77
P3S5	Oxygen Reduction Potential against pH	-0.642***	0.412	Y = 210.96 -19.6721x	26.5

Note: ** - significant at 1%, *** - significant at 0.1%
MAPE value: <10 – Best prediction, 10-20 – Good prediction, 20-50 – Reasonable prediction (Lewis, 1942), P1 – ENP, P2 – EPP, P3 – PPP, Sn – nth Sunny Day

Conclusion

- ❑ Pond water does not differ with respect to water quality among earthen production pond, earthen nursery pond and plastic production pond.
- ❑ Temperature, pH and Dissolved Oxygen follow an inverted U-shaped curve throughout the day; Total Dissolved Solid, Electrical Conductivity and Salinity remain similar while Oxygen Reduction Potential follows a more or less irregular pattern.
- ❑ Water quality parameters like Temperature, Dissolved Oxygen and pH goes above the acceptable range during daytime in summer season (especially in the month of May) in Rupandehi, a Terai district of Nepal.
- ❑ Water quality parameters have a strong relationship with each other and were found to have good predictability of values at a time for a certain pond type based on observation at other time of the same day.

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