TOPIC AREA:
PRODUCTION SYSTEM DESIGN & BEST MANAGEMENT ALTERNATIVES

EXPERIMENTAL POND UNIT ASSESSMENT IN KENYA

Production System Design & Best Management Alternatives /Activity/09BMA11UA

FINAL INVESTIGATION REPORT

Julius Manyala
University of Eldoret
Eldoret, Kenya

Kevin Fitzsimmons
University of Arizona
Tucson, Arizona, USA

ABSTRACT

Measurements of DO, temperature, conductivity, pH, hardness, TDS, total phosphates, bicarbonates and ammonia were undertaken from 11 February 2013 to 28 February 2013 as a preliminary assessment of the pond units under three fertilizer-feed regimes. The ponds were stocked with all male-tilapia. The experiments are aimed at assessing the pond productivity under different management regimes and to facilitate designing of production systems and Best Management Practices (BMP). The preliminary observations show that temperature increases during the day closely track the increase in the amount of dissolved oxygen in the ponds and that both fertilization and feeding enhance primary productivity. Both TDS and conductivity have been shown to be more elevated in fertilized-feed ponds as compared to only fed or fertilized ponds. The preliminary results of the study show promising indications that pond characterization can be done using water quality parameters as a background to enhancing production and implementing BMP.

INTRODUCTION

This pond characterization experiment has two goals;

i) Evaluate ponds at each research site for their physical, chemical, and biological characteristics during grow out, and
ii) To determine the ability of each research site to complete all of these measures.

The methods for pond characterization are well described in a number of publications, including Egna *et al*. (1987) and the *Standard Methods for the Examination of Water and Wastewater* (multiple versions of this are available, the most recent is APHA et al. 2012). The purpose of this report is to report on the preliminary results of a series of measurements that have already been carried out at the University of Eldoret Fish Ponds and the possible implication of these measurements.

METHODS

The preliminary data collected in February 2013 at 12 ponds at the University of Eldoret consisted of 4 control ponds receiving fertilization alone, 4 fully fed ponds with feed applied ad libitum, and 4 combined

ponds with both feed and fertilizer applied, feeding at half satiation (as determined in the second treatment).

All ponds were stocked with sex-reversed Nile tilapia (*Oreochromis niloticus*) at 2 fish m-2 obtained from Jewlet Farm. Fertilization commenced one week before stocking. Fertilization was done at 4 kg N and 1 kg P per hectare weekly on Saturday, starting one week before stocking, using local nutrient sources that are organic. Feeding was done twice daily at midday and evening. Locally available feeds were used in the experiments.

The feed was prepared on the campus from locally sourced ingredients. The experimental diet consisted of:

Table 1. *Experimental diet.*

Ingredient	**%**	Ingredients were ground in hammer mill to fine flour. Starting in April 2013, we plan to use meat mincer to make pellets.
Wheat bran	50	
Fish meal (*Rastrineobola argentea*)	25	
Cotton seed cake	10	
Sunflower cake	11	
Maize	4	
Total	100	

The feed was determined to have a crude protein content of 30%.

Dissolved oxygen and temperature were measured at two hour intervals from 06:00 to 18:00 daily. Water samples were collected from 5 cm below the water surface at 14:00 each day. Testing was conducted as soon as all the samples were collected in a shaded location avoiding direct sunlight.

Data presented in this report covers the month of February 2013 and spans a period of only 3 weeks. While further measurements are being undertaken and improved, the existing data already show some patterns to report as preliminary observations. At the end of 120 days, data, including yield, growth rate, and survival will be collected for fish from all treatments, and comparisons made using ANOVA. Changes in water quality between treatments and over time will be tested using ANOVA. In addition to chemical concentrations, diel measurements will be used to determine stratification in the ponds and primary productions rates. These will also be compared among treatments using ANOVA. The design and pond treatment is summarized in Table 2 below.

***Table 2**: Experimental design of the 12 ponds used in the study.*

POND	DESCRIPTION
B 3	Fertilizer and feeds
B4	Feeds
B5	Fertilizer
B6	Feed s
C3	Fertilizer
C4	Fertilizer and feeds
C5	Feeds
C6	fertilizer
D4	Fertilizer and feeds
D5	Fertilizer
D6	Fertilizer and feeds
D7	Feed

The temporal variation in DO mg L^{-1} for the three treatments show that DO in the fertilizer and feed ponds tracked higher for several of the days as compared to fertilizer alone or feed alone (Fig. 1). These variations were, however, not statistically significant between treatments ($F_{0.05(2),\ 2,1138} = 0.86$; $p = 0.422$) or in time (($F_{0.05(2),\ 13,1138} = 1.06$; $p = 0.387$).

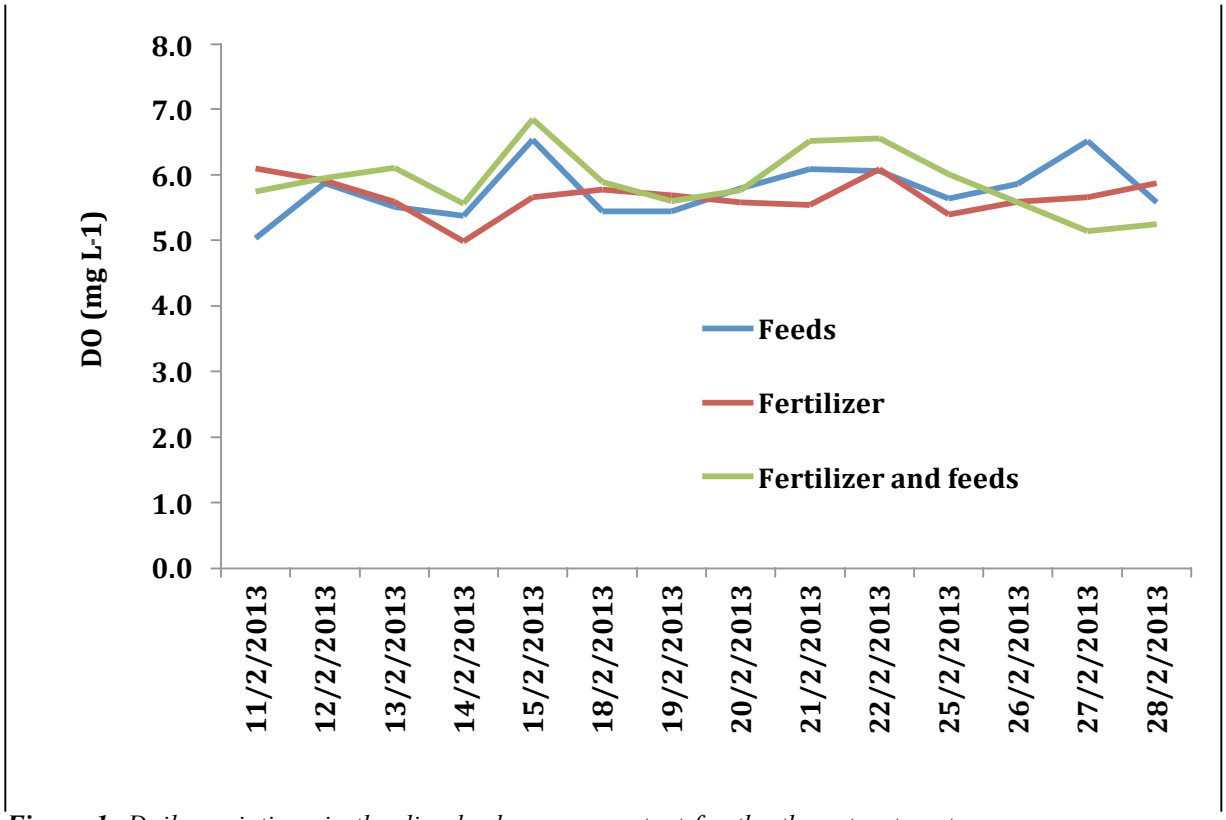

***Figure 1:** Daily variations in the dissolved oxygen content for the three treatments.*

The dissolved oxygen showed clear increase from early morning values of about 2 -3 mg L^{-1} at 06:00 Hrs to a maximum of 7-8 mg L^{-1} between 14:00 and 16:00 Hrs (Fig. 2). Variation in the value of DO during

the day were statistically significant ($F_{0.05(2),\ 6,1145} = 2396.25$; $p < 0.0005$) but was not significant between treatments ($F_{0.05(2),\ 2,1138} = 2.96$; $p = 0.052$). Maximum DO coincided with maximum temperatures and presumably the highest photosynthetic rate, during the same time of the day.

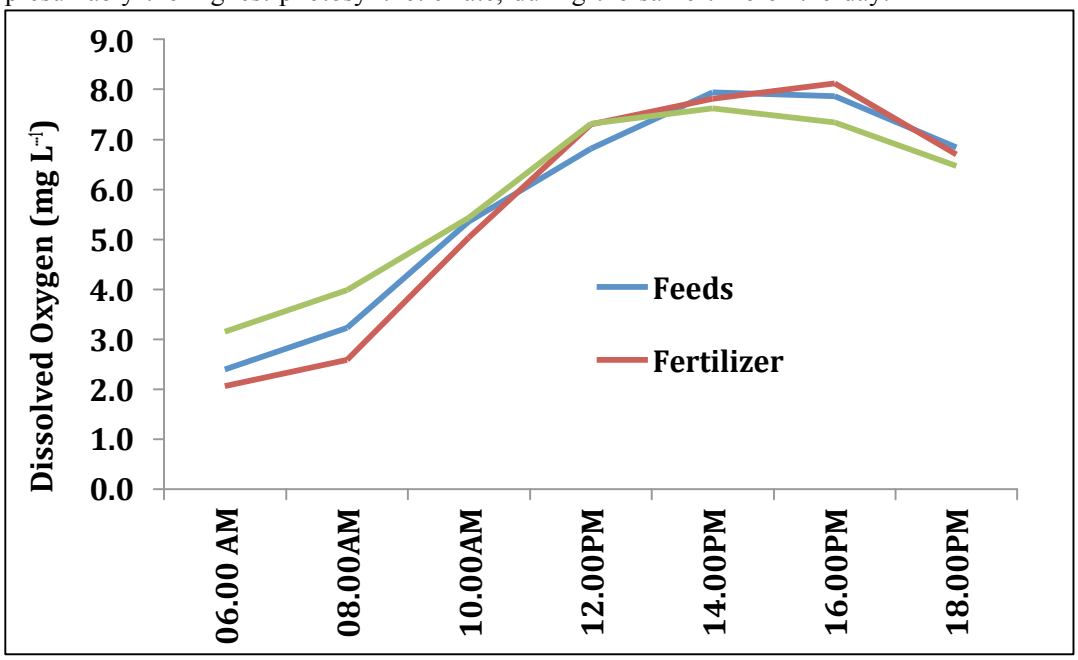

Figure 2: *Variations in the dissolved oxygen content with time of the day for the three treatments.*

The daily temperature variations were not statistically significant between treatments ($F_{0.05(2),\ 2,1138} = 2.65$; $p = 0.071$) nor between days ($F_{0.05(2),\ 2,1138} = 1.61$; $p = 0.076$) over the three week sampling period. However, slightly elevated temperatures were reported on 12/2/2013 and slightly depressed temperatures on 25/2/2013 (Fig. 3).

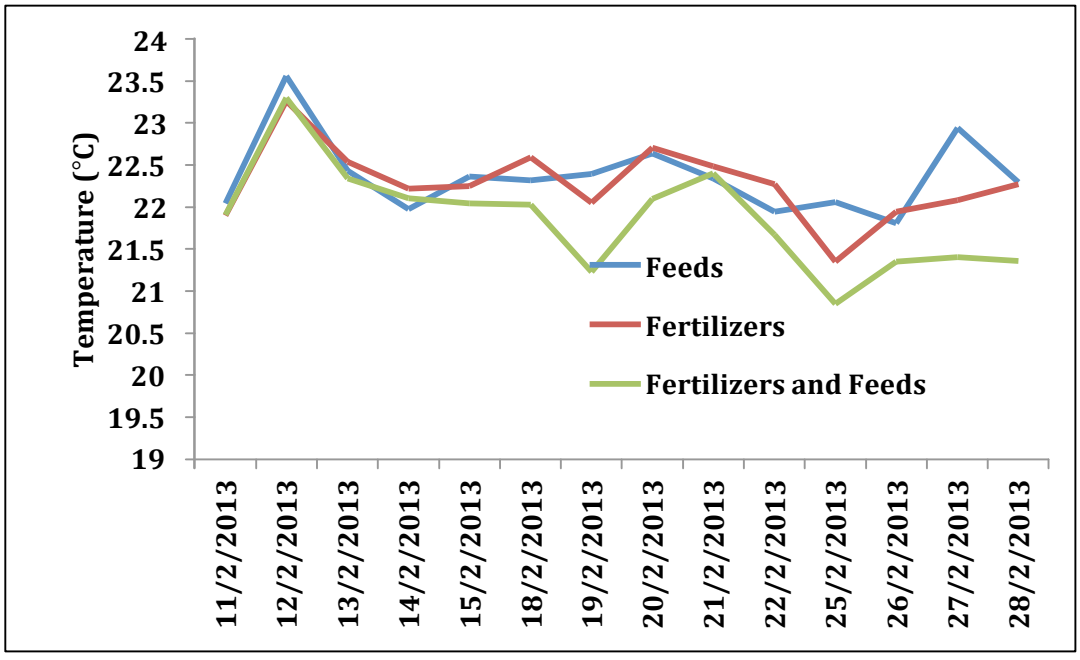

Figure 3: *Daily variations in pond water temperature for the three treatments.*

By-hourly measurements of temperature showed statistically significant variations between treatment ($F_{0.05(2),\ 2,1145} = 12.40$; $p < 0.0005$) and in time ($F_{0.05(2),\ 2,1145} = 813.94$; $p < 0.0005$) (Fig. 4). It is apparent that small variations in temperature in the ponds are likely to be responsible for changes in the dynamics of production, depending on the treatment (management) of the fish pond.

Further examination of the ANOVA model showed that there were many observations with large standardized residuals. The standardized residual is the residual divided by an estimate of its standard deviation. This form of the residual takes into account that the residuals may have different variances, which can make it easier to detect outliers. Standardized residuals greater than 2 and less than -2 are usually considered large and unusual. Due to these unusual or different variances, the conclusion that there were significant differences between treatments is treated with caution.

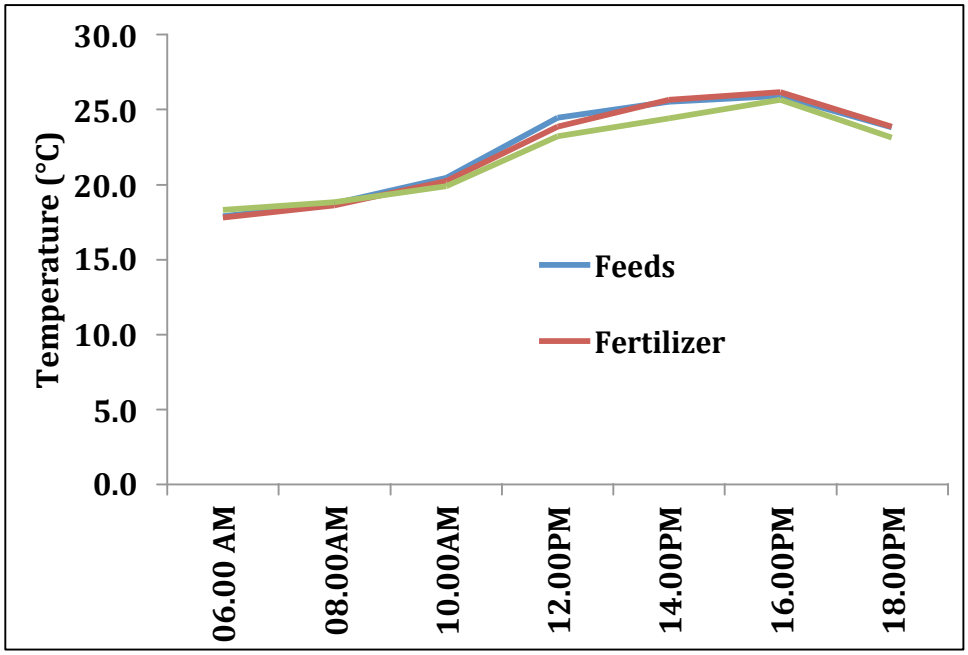

Figure 4: *Variations in pond water temperature with time of the day for the three treatments.*

The variations in conductivity among treatment showed relatively higher values in the fertilized and fed ponds as compared to only fertilized or only fed ponds (Fig. 5) by over 70 units in both cases. Alkalinity was, however, slightly lower in the fertilized and feed ponds as compared to only fertilized or only fed ponds by a range of tens. TDS was higher in fertilized ponds with feeds (263) as compared to only fertilized (217) and only fed ponds (207). Total hardness (44) was relatively lower in the fertilized pond as compared to the two other treatments while the bicarbonates were relatively similar in all treatments.

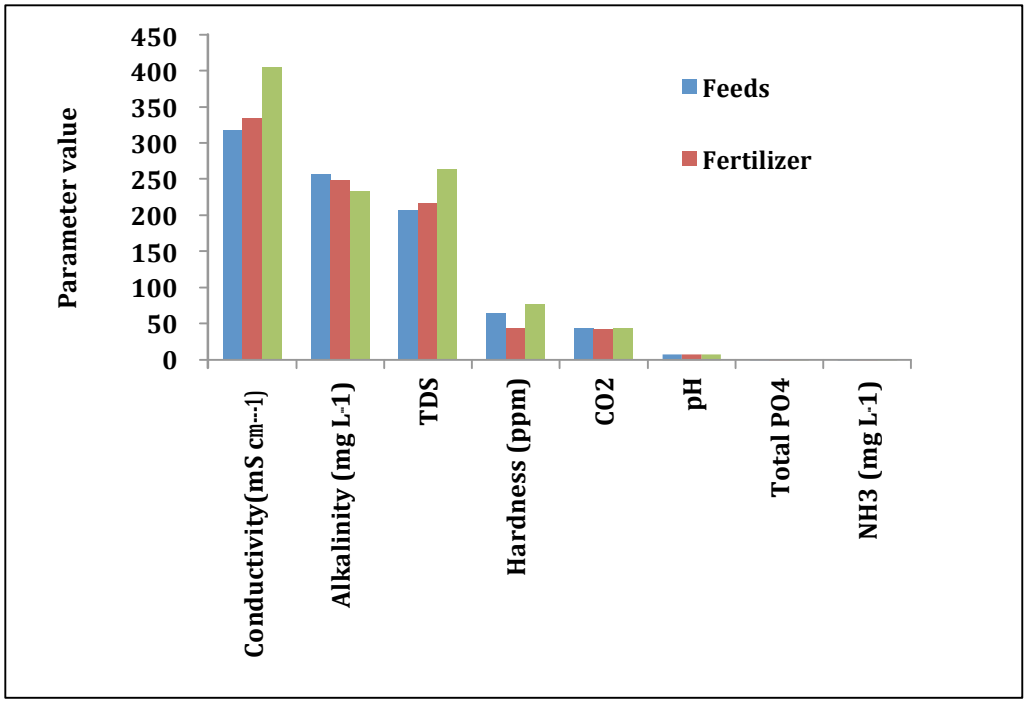

Figure 5. *Variations in selected water quality parameters for the three treatments.*

When the values were considered on a weekly basis, there was a general increase in alkalinity in the pond with fertilizer and feed while the bicarbonates were relatively constant in all treatments and over the weeks (Fig. 6). Both conductivity and TDS were relatively elevated in the pond with fertilizer and feeds as compared to the other treatments (values in week 3 only).

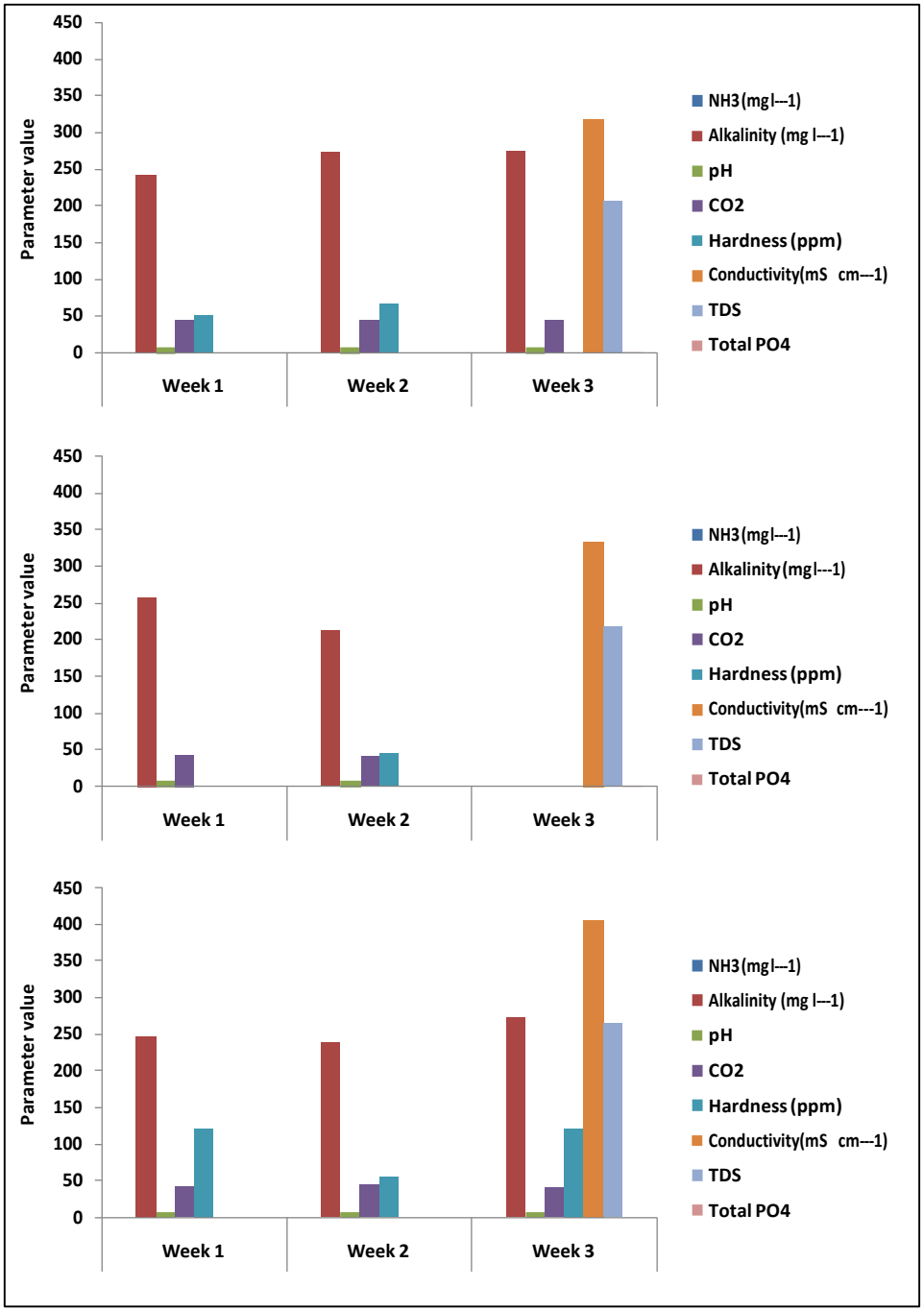

Figure 6. *Weekly variations in selected water quality parameters for the three treatments. Fertilizer, fed and fertilizer and fed, top to bottom, respectively.*

Table 3. *Analysis of Variance (ANOVA) tables for the measured water quality parameter with different treatments.*

General Linear Model: DO versus Treatment, Date

Factor	Type	Levels	Values
Treatment	fixed	3	Feeds, Fertilizer, Fertilizer and feeds
Date	fixed	14	11/2/2013, 12/2/2013, 13/2/2013, 14/2/2013, 15/2/2013, 18/2/2013, 19/2/2013, 20/2/2013, 21/2/2013, 22/2/2013, 25/2/2013, 26/2/2013, 27/2/2013, 28/2/2013

Analysis of Variance for DO, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	2	9.959	10.197	5.099	0.86	0.422
Date	13	81.621	81.621	6.279	1.06	0.387
Error	1138	6717.439	6717.439	5.903		
Total	1153	6809.019				

S = 2.42958 R-Sq = 1.34% R-Sq(adj) = 0.04%

General Linear Model: DO versus Treatment, Time

Factor	Type	Levels	Values
Treatment	fixed	3	Feeds, Fertilizer, Fertilizer and feeds
Time	fixed	7	06.00 AM, 08.00AM, 10.00AM, 12.00PM, 14.00PM, 16.00PM, 18.00PM

Analysis of Variance for DO, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	2	9.96	11.41	5.71	2.96	0.052
Time	6	4589.02	4589.02	764.84	396.25	0.000
Error	1145	2210.04	2210.04	1.93		
Total	1153	6809.02				

S = 1.38931 R-Sq = 67.54% R-Sq(adj) = 67.32%

General Linear Model: Temp versus Treatment, Date

Factor	Type	Levels	Values
Treatment	fixed	3	Feeds, Fertilizer, Fertilizer and feeds
Date	fixed	14	11/2/2013, 12/2/2013, 13/2/2013, 14/2/2013, 15/2/2013, 18/2/2013, 19/2/2013, 20/2/2013, 21/2/2013, 22/2/2013, 25/2/2013, 26/2/2013, 27/2/2013, 28/2/2013

Analysis of Variance for Temp, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	2	56.78	56.90	28.45	2.65	0.071
Date	13	224.97	224.97	17.31	1.61	0.076
Error	1138	12214.61	12214.61	10.73		
Total	1153	12496.36				

S = 3.27619 R-Sq = 2.25% R-Sq(adj) = 0.97%

General Linear Model: Temp versus Treatment, Time

Factor Type Levels Values
Treatment fixed 3 Feeds, Fertilizer, Fertilizer and feeds
Time fixed 7 06.00 AM, 08.00AM, 10.00AM, 12.00PM, 14.00PM, 16.00PM, 18.00PM

Analysis of Variance for Temp, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	2	56.8	51.2	25.6	12.40	0.000
Tme	6	10077.0	10077.0	1679.5	813.94	0.000
Error	1145	2362.6	2362.6	2.1		
Total	1153	12496.4				

S = 1.43646 R-Sq = 81.09% R-Sq(adj) = 80.96%

NEXT STEPS

The following issues are noted:

1. The project has acquired weather data that will be incorporated in the analysis.
2. The nitrates/nitrites determination seems to be below detectable range and this will be resolved when we acquire the Kjeldahl Unit.
3. Measurement on chlorophyll-a was not possible in February but measurements have commenced in March.
4. Some administrative hitches on procurements are being addressed.