Aquaculture in the Classroom Newsletter
Volume 5, No.7, July 2017

Dear Aquaculture Enthusiasts:

Welcome to July. This newsletter will introduce you to some new resources available for reference and educational purposes. Do we use math is aquaculture? Yes, yes we do. This edition will concentrate on aspects of math used in aquaculture that should be used in the classroom. Remember to plan for Aquatic Sciences Day in September. We need you. We look silly with all our special demonstrations and gizmos neatly displayed if no one comes to see them. The demonstrations and gizmos are all concepts or demonstrations you can use in the classroom. We hope to see you there. Lastly, come visit the UAPB booth at the FFA Ag In-service August 1-4 at Camp Couchdale.

Math in Aquaculture

Recently, my daughter, an art history major said, “I’m not good at math.” I replied, “Yes you are. You don’t care to do it, but you are actually good at it, especially when you consider the physics calculations and calculus you’ve done in the past.” Of course part of her proclamation comes from the fact she is dating an aeronautical engineer and some of the math he does is difficult and beyond her current scope. That does not mean she is not good at math. Many students graduate high school believing they are not good at math. We can use math in aquaculture to help them see they are, in fact, good at math, even though the level we use is humble compared to rocket scientists. Even so, rocket scientists have to be able to do the humble math (such as converting from English to metric units) or the rocket science math may come to naught. You may recall some years ago, there was a Mars landing unit that crashed into the planet because one rocket scientist did not make the conversions. This newsletter will demonstrate a few of the many possible applications of math in our aquaculture classes. This may carry some students to aquaculture and fisheries or lay their foundation for rocket science, or art history.

AMMONIA

TAN (total ammonia as nitrogen) is composed of two parts: 1) ammonia, NH_3 and 2) ammonium ion, NH_4^+. The equation is TAN = $NH_3 + NH_4^+$. The test we use to find ammonia is the total ammonia test. The results of the test tell us all the ammonia that is in the water, but does not differentiate between ammonia and ammonium ion. Ammonia is toxic to fish and ammonium ion is not. We need to use math and two more tests to find out if the fish are safe.

EXAMPLE: Gather data

pH = 7.4

T = 26C

TAN = 5 ppm

Using Table 22 below, find the coefficient by which to multiply the TAN. The intersection of pH 7.4 and 26C is 0.0150.

5 ppm x 0.0150 = 0.075 ppm of NH_3 that is toxic to the fish.

How much of the TAN is not toxic to the fish?

TAN = NH_3 + NH_4^+

Substitute

5ppm = 0.075 ppm + NH_4^+

5 ppm – 0.075 ppm = NH_4^+

4.925 ppm = NH_4^+ ammonium ion that is not toxic to the fish.

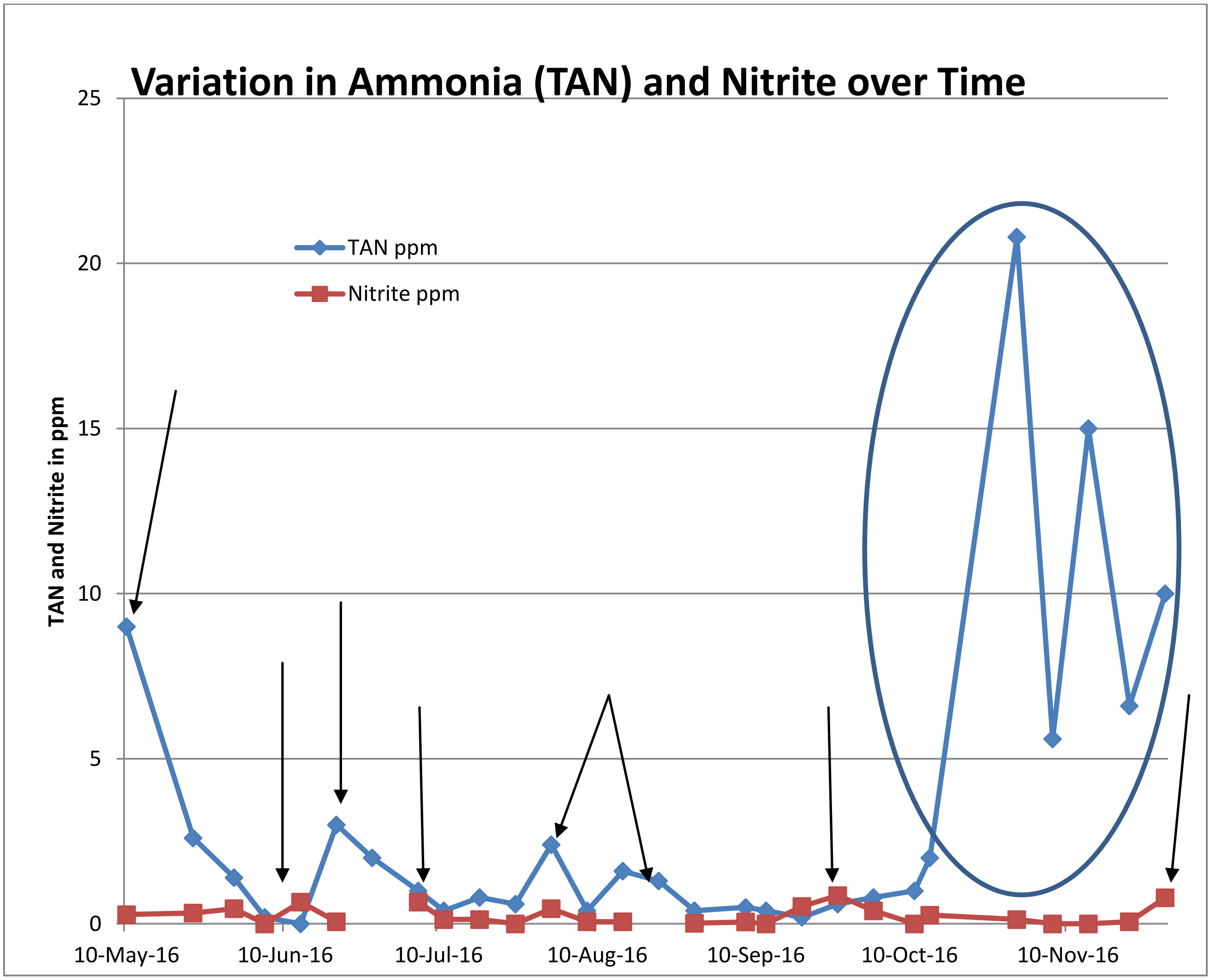
Table 22. Fraction of toxic (un-ionized) ammonia in aqueous solution at different pH values and temperatures.

	(Temperature °C)												
pH	6	8	10	12	14	16	18	20	22	24	26	28	30
7.0	0013	.0016	.0018	.0022	.0025	.0029	.0034	.0034	.0039	.0046	.0052	.0069	.0080
7.2	0021	.0025	.0029	.0034	.0040	.0046	.0054	.0062	.0072	.0083	.0096	.0100	.0126
7.4	.0034	.0040	.0046	.0054	.0063	.0073	.0085	.0098	.0114	.0131	.0150	.0173	.0198
7.6	.0053	.0063	.0073	.0086	.0100	.0116	.0134	.0155	.0179	.0208	.0236	.0271	.0310
7.8	.0084	.0099	.0116	.0135	.0157	.0182	.0211	.0244	.0281	.0322	.0370	.0423	.0482
8.0	.0133	.0156	.0182	.0212	.0247	.0286	.0330	.0381	.0438	.0502	.0574	.0654	.0743
8.2	.0210.	0245.	0286.	0332	.0385	.0445	.0514	.0590	.0676	.0772	.0880	.0998	.1129
8.4	.0328	.0383	.0445	.0517	.0597	.0688	.0790	.0904	.1031	.1171	.1326	.1495	.1678
8.6	.0510	.0593	.0688	.0795	.0914	.1048	.1197	.1361	.1541	.1737	.1950	.2178	.2422
8.8	.0785	.0909	.1048	.1204	.1376	.1566	.1773	.1988	.2241	.2500	.2774	.3062	.3362
9.0	.1190	.1368	.1565	.1782	.2018	.2273	.2546	.2836	.3140	.3456	.3783	.4116	.4453
9.2	.1763	.2008	.2273	.2558	.2861	.3180	.3512	.3855	.4204	.4557	.4909	.5258	.5599
9.4	.2533	.2847	.3180	.3526	.3884	.4249	.4618	.4985	.5348	.5702	6045	.6373	.6685
9.6	.3496	.3868	.4249	.4633	.5016	.5394	.5762	.6117	.6456	.6777	.7078	.7358	.7617
9.8	.4600	.5000	.5394	.5778	.6147	.6499	.6831	.7140	.7428	.7692	.7933	.8153	.8351
10.0	.5745	.6131	.6498	.6844	.7166	.7463	.7735	.7983	.8207	.8408	.8588	.8749	.8892
10.2	.6815	.7152	.7406	.7746	.8003	.8234	8441	.8625	.8788	.8933	.9060	.9173	.9271

To calculate the amount of un-ionized (toxic) ammonia present, find the fraction of ammonia that is in un-ionized form for a specific pH and temperature from the table. Multiply this fraction by the total ammonia nitrogen present in a sample to determine the ppm of un-ionized ammonia.

Tilapia need an NH_3 level less than 0.2 ppm. In this example, the NH_3 is 2.6 times less than the maximum allowed (0.2ppm/0.075ppm = 2.67ppm) so ammonia is not a problem for these fish.

This graph below shows changes in ammonia and nitrite in an RAS over 6 months. Nitrite levels are very small compared to ammonia levels, so it can be difficult to see large changes in nitrite in this graph, but also remember that small changes in nitrite are also large changes for fish as far as toxicity is concerned.



The arrows show a high TAN or high nitrite. You will notice that after a high TAN, the nitrite will rise later. The circled area shows a series of high TAN levels that lead to the last arrow which is almost the highest nitrite level attained in the series. The circled area was due to very heavy feeding resulting from about 30 lbs of new fish transferred into the system. By testing the water, keeping track of the data, and using a graph, the students can see when bacterial colonies expanded. With the first arrow, the system is new and *Nitrosomonas* bacteria are not available in sufficient numbers to process the ammonia. By the second arrow, *Nitrosomonas* are eating the ammonia, so that level has diminished. Then the nitrite level increases because *Nitrosomonas* waste is accumulating but the Nitrobacter colony has not yet responded. During the next two weeks, nitrite decreases because with plenty of nitrite to eat, the *Nitrobacter* colony expands. More data could be included on this graph. Feeding rate would show why the ammonia increases. Weekly estimates of biomass would also show reasons for changes in ammonia and nitrite. If fish were harvested levels would diminish, if they were stocked, levels would increase. A class can make this happen by changing amounts of feed. For example, the system can be underfed for awhile and then fed heavily.

CARBON DIOXIDE

It is possible to test for carbon dioxide (CO_2), but the test is often unreliable. However, there are other tests we perform frequently that, when exposed to a little math, reveal the CO_2 in the system. The students get to perform more math and the budget saves buying another test. I call this win-win.

EXAMPLE: Gather data

pH = 7.2

T = 77F

Alkalinity = 100 ppm

Using Table 23 below, find the coefficient by which to multiply the alkalinity and thereby calculate the CO_2 level in the system. The intersection of pH 7.2 and temperature 77F is 0.124.

100 ppm x 0.124 = 12.4 ppm of CO_2 in the system.

Aquaculture Producer's Quick Reference Handbook

Table 23. Factors for calculating carbon dioxide concentrations in water with known pH, temperature and total alkalinity measurements.

pH	5/41	10/50	15/59	20/68	27/77	30/86	35/95
6.0	2.915	2.539	2.315	2.112	1.970	1.882	1.839
6.2	1.839	1.602	1.460	1.333	1.244	1.187	1.160
6.4	1.160	1.010	0.921	0.841	0.784	0.749	0.732
6.6	0.732	0.637	0.582	0.531	0.495	0.473	0.462
6.8	0.462	0.402	0.367	0.335	0.313	0.298	0.291
7.0	0.291	0.252	0.232	0.211	0.197	0.188	0.184
7.2	0.184	0.160	0.148	0.133	0.124	0.119	0.116
7.4	0.116	0.101	0.092	0.084	0.078	0.075	0.073
7.6	0.073	0.064	0.058	0.053	0.050	0.047	0.046
7.8	0.046	0.040	0.037	0.034	0.031	0.030	0.030
8.0	0.029	0.025	0.023	0.021	0.020	0.019	0.018
8.2	0.018	0.016	0.015	0.013	0.012	0.012	0.011
8.4	0.012	0.010	0.009	0.008	0.008	0.008	0.007

To calculate the carbon dioxide level (ppm), find the corresponding factor from the table and multiply that factor times the total alkalinity.

Fish should be exposed to less than 15ppm of CO_2. So the fish in this system are okay. But if the pH drops lower than 7.1 under these conditions, CO_2 will be greater than 15 ppm*, a potential problem. (*based on using the average of 0.124 and 0.197, or 0.161)

BAKING SODA ADDITION TO CONTROL pH

As feed is introduced into the RAS, biological processes to utilize the feed and manage its waste create acid and cause the pH to drop. Over time this can be very dangerous to the fish. Base or alkallinity must be added to the RAS to counteract the acid development. With an important piece of data and some math, we can calculate approximately how much baking soda to put into the RAS. It is still necessary to check pH, but this baking soda addition will slow down the pH peaks and valleys.

EXAMPLE: Gather data

Feed fed to the RAS in one week = 20 lbs

A rule of thumb for counteracting acid production in an RAS is to add 142g of baking soda for every 1000g of feed given to the fish. This means we need to use math to get everything in the same units and to calculate how much baking soda to add.

We can set it up as a proportion:

$$\frac{\text{142g baking soda}}{\text{1000g fish feed}} = \frac{\text{x lbs baking soda}}{\text{20 lbs fish feed}}$$

$$\frac{\text{20 lbs fish feed x 142g baking soda}}{\text{1000g fish feed}} = \text{x lbs baking soda}$$

2.84 lbs of baking soda needed in the RAS.

An hour after adding the baking soda, the pH should be checked to verify the baking soda did the job. (Also consider how much the pH will change with the addition of baking soda. If it will change more than 0.5 pH in 15 minutes, the addition of baking soda needs to be slowed down.) This calculation can also lead to calculating how much baking soda will be needed per month to assist with the RAS budget.

FOOD CONVERSION RATIO

Food Conversion Ratio (FCR) is a useful management tool and it should be calculated to let the operator know how efficient the operation is.

$$\text{FCR} = \frac{\text{Quantity of food fed}}{\text{Amount of weight gained by the fish}}$$

EXAMPLE: Gather data

Total number of fish stocked = 100

Total weight of fish stocked = 1 lb

Total weight of fish harvested = 95 lbs

Total weight of feed fed = 178 lbs

Substitute FCR = $\frac{\text{Quantity of food fed}}{\text{Amount of weight gained by the fish}}$

FCR = $\frac{\text{178lbs of feed}}{\text{95 lbs fish harvested – 1 lb stocked}}$

FCR = $\frac{\text{178 lbs of feed}}{\text{94 lbs of fish weight gained}}$

FCR = 1.89

Tilapia FCR should be between 1.5 and 2.0, so these fish are on target. For the purposes of this calculation, more data were given than needed. But if a sample was taken every 2-3 weeks, estimates of FCR could be calculated.

EXAMPLE:

20 fish sampled

Total weight = 3.5 lbs

Total feed fed = 33 lbs

20 fish is 1/5 of the population and if we cannot account for any mortalities, we still have 100 fish in the RAS. We can estimate the total weight in the RAS at this time:

3.5 lbs of fish x 5 = 17.5 lbs of fish in the RAS

Substitute FCR = $\frac{\text{Quantity of food fed}}{\text{Amount of weight gained by the fish}}$

FCR = $\frac{\text{33 lbs of feed}}{\text{17.5 lbs fish harvested – 1 lb stocked}}$

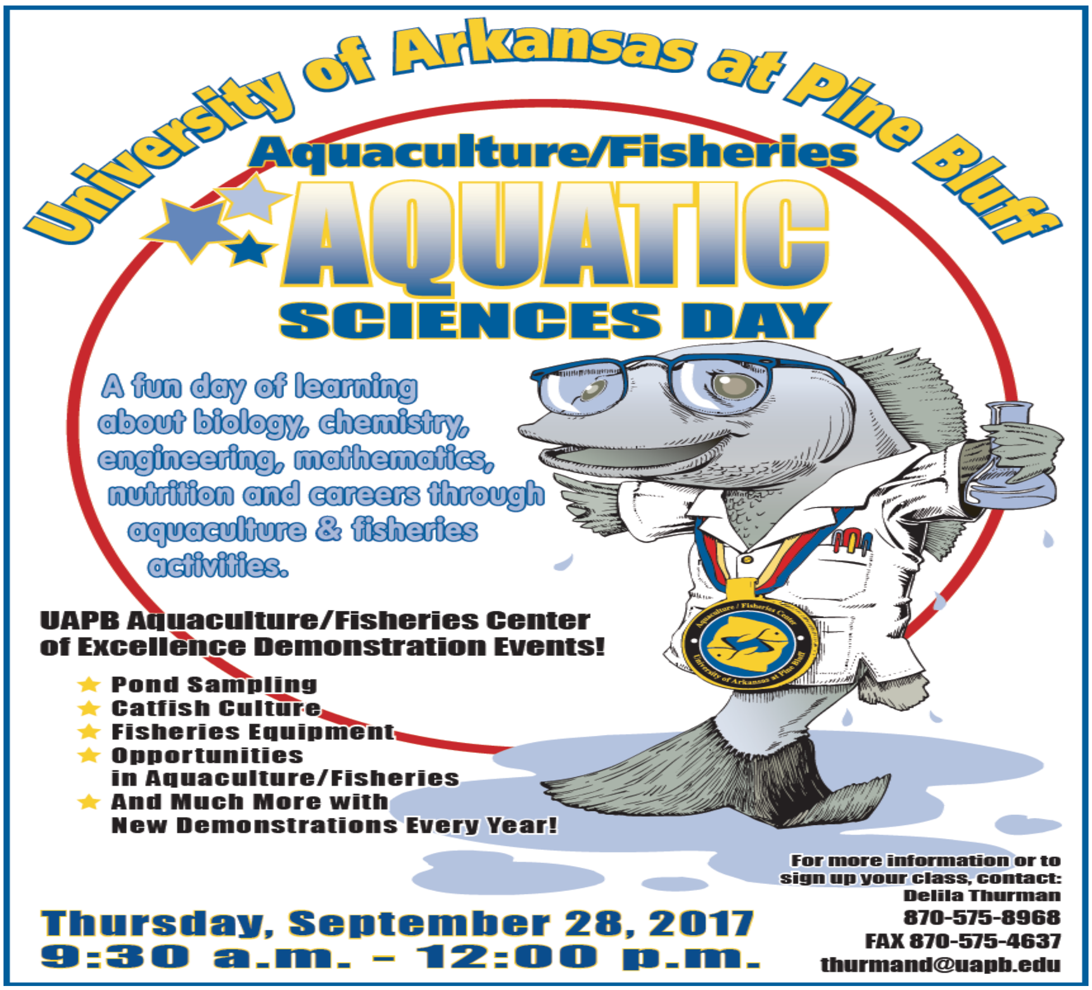
FCR = $\frac{\text{33 lbs of feed}}{\text{16.5 lbs of fish weight gained}}$

FCR = 2.0

At this point, we are at the high end of the acceptable range of feeding. We can take time to figure out why the fish are not gaining weight as efficiently as if the FCR was 1.5. This helps with management. If we compare the FCR at 1/3 of the production cycle completed to the final FCR calculation, we see that feeding and growth became more efficient over time. It is also possible that the fish we caught for the sample were the smaller fish in the population and did not correctly reflect all the growth in the system at that point.

Come to Aquatic Sciences Day, 2017

2017 is an odd-number year and that means Aquatic Sciences Day will be here in the fall. Visit ASD video 2015: https://www.youtube.com/watch?v=gZ1X7XsXVJQ. See the flyer at: http://www.uapb.edu/sites/www/Uploads/AQFI/News/AF_Aquatic_Sciences_Day_2017_Flyer.pdf. To sign up for Aquatic Sciences Day 2017 on Thursday, September 28, from 9:30 a.m. – 12:00 p.m., call Delila Thurman at 870-575-8968 or email her at thurmand@uapb.edu.



Now is the time to plan for this event. Call 870.575.8968 and register your class today!

New Factsheets are Available

Are you a new teacher who inherited an old system? These publications may help you operate and repair those systems.

Understanding and maintaining Older Classroom Recirculating Aquaculture Systems
https://www.uaex.edu/publications/pdf/FSA-9620.pdf.

Repairing and Upgrading Older Classroom Recirculating Aquaculture Systems
https://www.uaex.edu/publications/pdf/FSA-9621.pdf.

Remember, if you need me, call 870.575.8143 or email dukeb@uapb.edu.

Best Fishes,
Bauer