Water Quality Research or Water Quality Checking: Proposed Guidelines*

BARRY A. COSTA-PIERCE
ICLARM/GTZ Africa Aquaculture Project
P.O. Box 229, Zomba, Malawi

Introduction

Aquaculture research programs are primarily concerned with fish biological and production phenomena (yield characteristics and growth), and the experimental and environmental factors causing observed differences between treatments.

One of the major problems in aquaculture science is ensuring that treatments exert statistically discernible effects on biological or production processes. However, water quality differences between replicates can lead to wide variabilities within treatments which can confound the most beautifully constructed set of factorial experiments. Many parameters can interact synergistically over various time periods to stress fish or cause mortalities. It is thus important that water quality be closely monitored so that scientific decisions can be made if treatments themselves or water quality factors (or a mixture of the two) have exerted major influences on fish growth and production.

Decisions about choosing which water quality parameters to monitor, how frequently and over what periods are an essential part of the planning of aquaculture experiments. Unfortunately, these decisions are often made without adequate guidelines. Researchers often measure either too much or too little or make measurements at inappropriate times, thereby wasting resources and producing data of limited use or validity. While excellent aquaculture water quality chemistry texts (Boyd 1982) and analytical handbooks (Stirling 1981; APHA 1989) exist, a simple guideline to help standardize and structure water quality programs at the planning stage is lacking.

A simple plan is outlined here to assist in the design of water quality research and monitoring programs at aquaculture research stations. The plan is the result of practical experiences in arranging a water quality program to suit the needs of a large research project (ICLARM/GTZ Africa Aquaculture Project, Zomba, Malawi) for monitoring 69 experimental ponds and 110 cement tanks receiving a diverse variety of inputs, mainly agricultural byproducts.

Planning a Water Quality Monitoring Program

Before monitoring any program a decision on the goals of the aquaculture research to be performed is crucial to planning.

If the experimental objectives are to answer testable aquaculture *production* hypotheses,

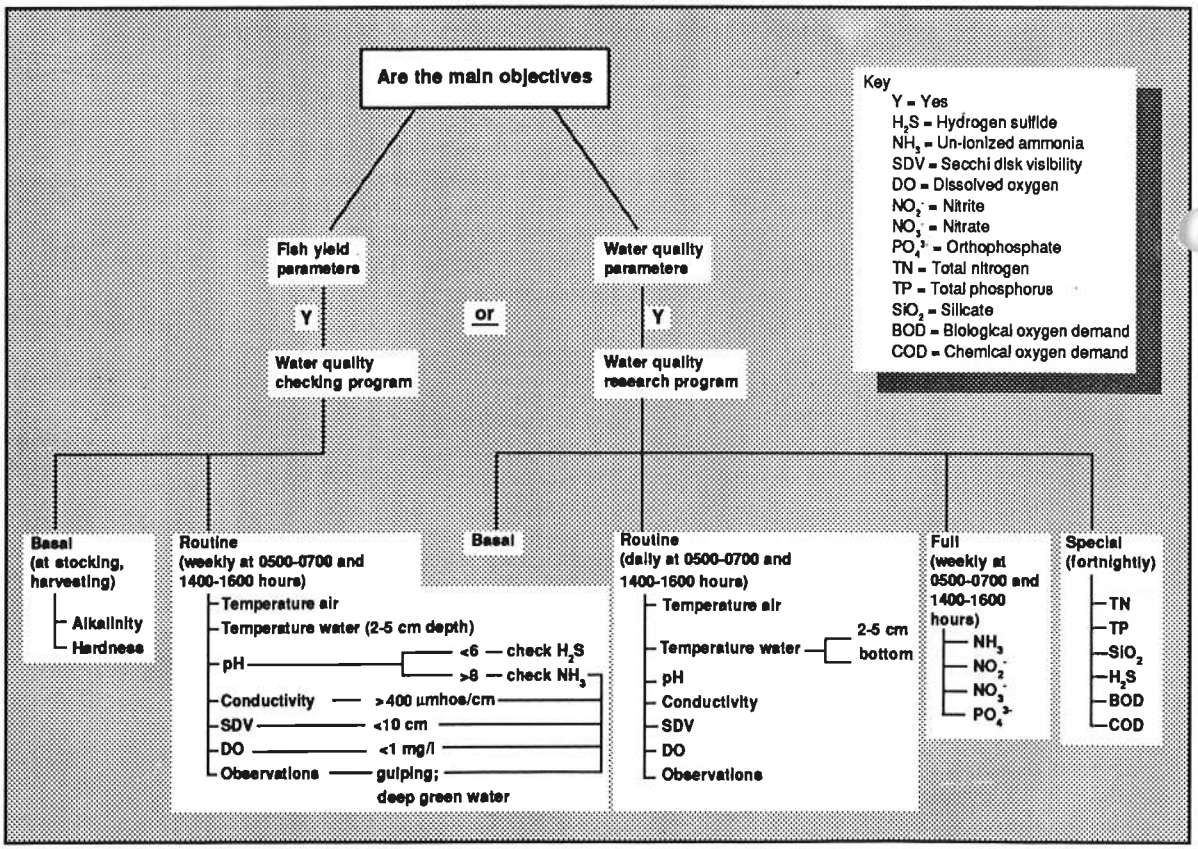

Fig. 1. Plan used to guide water quality monitoring programs in aquaculture research.

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e.g. fish yield parameters, the plan requires a water quality *checking* pathway. If hypotheses about water quality, pond dynamics or chemical/gas cycles and how these impact fish are more important, a water quality *research* pathway is followed (Fig.1).

Water Quality Checking

In water quality checking, *basal* and *routine* (weekly) parameters are monitored at stocking and harvesting fish. The two most important basal parameters for freshwater fish culture are alkalinity and hardness. These are not critical to fish health on short time scales and change slowly over most culture periods, unless regular liming is being conducted.

Routine water quality monitors (on a weekly basis) parameters that can change rapidly and can dramatically affect fish health and experimental treatments. Surface water temperatures (at 2-5 cm depth) and pH are measured weekly at 0500-0700 and 1400-1600 hours because of their central positions as primary indicators of whether toxic concentrations of ammonia or hydrogen sulfide occur. If the pH is out of the range for good fish growth (6-8), or conductivity, Secchi disk visibility (SDV), dissolved oxygen (DO), or observations exceed the limits shown in Fig. 1, further investigations are required. It is essential that all routine water quality measurements be conducted during the critical early-morning and late-afternoon (0500-0700 and 1400-1600 hours) periods.

When adverse pH's occur during a routine water quality checking program, testing for concentrations of un-ionized hydrogen sulfide (H_2S) or ammonia (NH_3) is also conducted. Fig. 1 details testing needs if: pH's are less than 6.0 (at 0500-0700 hours) or greater than 8.0 (at 1400-1600 hours); conductivities exceed 400 µmhos/cm; SDV falls below 10 cm; 0500-0700 hours DO falls below 1 mg/l; and/or morning observations show fish gulping at the water surface and a deep green water color.

Water Quality Research

DO and pH are the most critical parameters to measure on a regular basis in aquaculture, especially in experiments using high stocking densities close to the carrying capacity of the system, or with high feeding/loading rates of organic matter and during warm seasons.

Water quality *research* should include *routine* (daily) monitoring of DO, pH and other parameters at 0500-0700 and 1400-1600 hours (Fig. 1). Water temperatures are taken at the surface (2-5 cm depth) and at the pond bottom, in order to monitor pond mixing dynamics. *Full* water quality monitoring involves weekly measurements of inorganic nutrients important for primary and total microbial production to determine interactions among carbon and nutrient pathways.

Monitoring *special* water quality parameters every two weeks allows complete determination of organic and inorganic pathways. For example, nutrient and silica cycling, sulfur cycling, biological and chemical interactions and respiratory pathways can be examined.

Suggested Further Reading

APHA (American Public Health Association). 1989. Standard methods for the examination of water and wastewater: supplement to the seventeenth edition. APHA, AWWA, WPCF, Washington, DC.

Boyd, C.E. 1982. Water quality management for pond fish culture. Elsevier Scientific Publishing, Amsterdam.

Stirling, H.P., editor. 1985. Chemical and biological methods of water analysis for aquaculturists. Institute of Aquaculture, University of Stirling, Stirling, Scotland.

Is ANOVA Powerful Enough for Analyzing Replicated Pond Experiments?*

A.A. VAN DAM

ICLARM/GTZ Africa Aquaculture Project
P.O. Box 229, Zomba, Malawi

Introduction

Aquaculture pond experiments, like agricultural crop trials, are often designed according to the statistical rules of replication and randomization: several treatments are applied to a number of experimental units (in this case: ponds) after which a certain characteristic (e.g., yield) is measured in every pond. Other factors with a possible effect on the measured characteristic are held at the same constant level as much as possible so as not to disturb treatment effects. Analysis of variance (ANOVA) is used to compare the treatments.

Other things than the treatments alone can cause differences between ponds. This 'experimental error' has to be estimated by assigning the same treatment to more than one pond: replication. Treatment effects are 'between group' differences whereas 'within group' differences are 'error'. If there is much more variation between groups than within, groups are obviously very different from each other and there may be a significant treatment effect.

Randomization (random assignment of treatments to ponds) is necessary because the observations and the errors must be independently distributed in order to test hypotheses. The null hypothesis (H_0): 'all treatment means are equal' is tested against the alternative (H_1): 'the means are not equal'.

H_0 can be true or false. The value α indicates the probability of rejecting the null hypothesis when H_0 is true. This mistake (rejecting H_0 although it is true) is called a Type I error. The value of α is usually set at 0.05 or even lower to ensure that making a Type I error is very unlikely.

When H_0 is false, the value β indicates the probability of not rejecting H_0, which would also be a mistake: this is called a Type II error. Interestingly, α-levels are

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