RECENT ADVANCES IN WATER QUALITY MONITORING IN AQUACULTURE

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SAVREMENI PRISTUPI U MONITORINGU KVALITETA VODA U AKVAKULTURI

Apstrakt

Merenje fizičkih, hemijskih, bioloških parametara je važno za praćenje stanja kvaliteta voda, a samim tim i veoma važno i u akvakulturi. Visokofrekventna merenja kvaliteta voda se poslednjih godina uspešno obavljaju i u Srbiji upotrebom multiparametarske sonde, jednostavne za rukovanje a složene po pitanju parametara koje može meriti u istom trenutku. Potreba za kontrolom kvaliteta vode raste sa povećanjem produkcije ribnjaka. Od ekstenzivnog gajenja, poluintezivnog, preko intenzivnog i superintenzivnog gajenja ribe, proces kontrole kvaliteta vode se usložnjava, dakle od povremenog kontrolisanja kvaliteta (mesečno, kod ekstenzivne proizvodnje), preko dnevne, kontrole na sat, i konačno do kontinuiranog praćenja kontrole kvaliteta (super-intenzivno). Praćenje kvaliteta senzorima i sondom je moguce u svim navedenim tipovima ribnjaka, ali je svakako primena takve metode najpotrebnija u superintenzivnoj ribnjačkoj proizvodnji.

Ključne reči: kvalitet vode, visoko frekventana merenja, monitoring, fish, akvakultura
Keywords: water quality, high frequent measurements, monitoring, fish, aquaculutre

INTRODUCTION

Water can dissolve more substances than any other liquid. Over 50 percent of the known chemical elements are found in natural waters (http://www.extension.org/). Successful aquaculture depends on healthy fish and proper water quality management. Fish diseases usually occur after stress from impaired water quality. Most important parameters to be monitored regarding water quality in every fish pond are: temperature, dissolved oxygen, nitrogenous compounds, pH, alkalinity, hardness, carbon dioxide, salinity, iron, chlorine, hydrogen sulfide, water clarity. If the productivity of pond is maintained at high densities, the temperature, dissolved oxygen, ammonia, nitrite, and pH should be monitored daily or more frequently, while clarity of the water, alkalinity, hardness can be measured less frequently, perhaps one or two times per week. Other parameters like salinity, iron, and chlorine should be determined when a water source is planned to be examined, then corrective measures may be done directly during the design (Buttner et al., 1995).

Intensive monitoring of the water quality using multiparameter probes and temperature loggers in Serbia is in its infancy. Some measurements have been conducted at reservoir lakes: Ćelije, Gruža and Vrutci and on Lake Sava, small artificial urban lake in Belgrade. Continuous measurements of water temperature were established on Lake Sava in Belgrade by the aid of high frequency temperature loggers.

MATERIAL AND METHODS

We have started to collect water temperature data with temperature HOBO sensors in real-time, off line manner while other parameters were collected once per month with the multiparameter probe YSI 6600 V2-2. Most of our surveys were conducted on Lake Sava. This lake is an immensely popular recreational zone, which has the status of a special fishing water body ("catch-and-release fishing"). This lake can be observed as an extensive pond, inhabited by 20 introduced fish species (Hegediš et al., 2008). The community is dominated by cyprinid fish species with significant presence of invasive, allochthonous fish species.

Data from HOBO temperature loggers HOBO UA-001-64 are collected with 15 minutes frequency. Ten HOBO temperature loggers hang on a string at ten different depths (in meters): 0; 0.5; 1; 1.5; 2.5; 3.5; 4.5; 5.5; 6.5 and 7.5.

Multiparameter water quality probe YSI 6600 V2-2 collect water quality data by using indicators that can be measured at the same time: water temperature, pH value, conductivity, TDS, DO (luminescence time based optical sensor), DO saturation, Chlorophyll *a*.

RESULTS AND DISCUSSION

After oxygen, water temperature is the most important factor affecting the welfare of fish. Selection of species should be based in part on the temperature of the water. The temperature of the water affects the activity, behavior, feeding, growth, and reproduction of all fishes. Metabolic rates in fish depend on the temperature. Fish are generally categorized into warmwater, coolwater, and coldwater species based on optimal growth temperatures. Temperature also determines the amount of dissolved gases (oxygen, carbon dioxide, nitrogen, etc.) in the water. Figure 1 presents records of water temperature in 15 minutes intervals on 5 different depths measured at Lake Sava from May 23rd to June 2nd. Presence of water column stratification is obvious and sensors are capable of measuring both, daily and diurnal changes in water temperature. In this part of the season fish settle in a certain part of water column in accordance with their preference to water temperature.

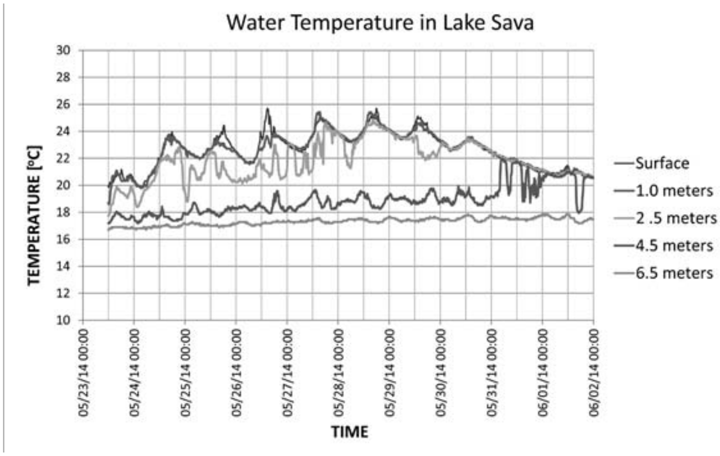

Figure 1. Temperature records at Lake Sava, five depths from May 23rd to June 2nd

Dissolved oxygen (DO) is the most important chemical parameter in aquaculture (Simões et al., 2008). Low-dissolved oxygen levels are responsible for more fish kills, than all other problems combined. Smaller size fish consume more oxygen because of their higher metabolic rate. Dissolved oxygen requirements in parts per million (ppm) for fish are: 5-10 safe, 3-5 caution, 0-3 lethal. Figure 2 shows DO vertical profiles in period of summer thermal stratification. DO concentrations are quite uniform over the depth with the exception of hypoxic conditions near the of bottom sediments observed in August 2014. This could affect benthic fish species.

Other important parameters to be monitored regarding water quality in every fish pond are: nitrogenous compounds, pH, alkalinity, hardness, carbon dioxide, salinity, iron, chlorine, hydrogen sulfide, water clarity. All of these parameters could be measured directly or indirectly in real time by the use of water quality sensors.

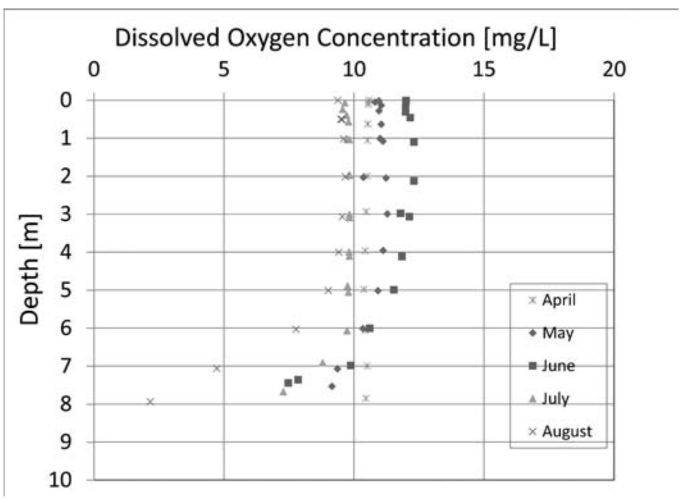

Figure 2. Vertical profiles of DO measured in spring and summer of 2014 at Sava Lake.

Two forms of ammonia occur in aquaculture systems, ionized and un-ionized. The un-ionized form of ammonia (NH_3) is extremely toxic, while the ionized form (NH_4^+) is not. Both forms are grouped together as „total ammonia.” Un-ionized ammonia levels rise as temperature and pH increase.

The quantity of hydrogen ions (H^+) in water will determine if it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. pH levels may fluctuate in ponds from approximately 4-5 to over 10 during the day. In recirculating systems constant fish respiration can raise carbon dioxide levels high enough to interfere with oxygen intake by fish, in addition to lowering the pH of the water. The acceptable range for fish culture is normally between pH 6.5-9.0.

Conductivity is commonly used in aquaculture systems for monitoring of amount of salts, nutrients or impurities in the water. Generally it is used to measure concentration of ionized chemicals in water (Zhang et al., 2013). It can be used as indicator of primary production (chemical richness) and thus fish production (Bhatnagar and Devi, 2013).

There is an interacting effect of oxygen saturation and ammonia level on fish growth (Foss et al., 2003). Increased toxicity of ammonia was observed with decreasing oxygen level. Under reduced oxygen level most of the mortality occurs within a few hours, apparently as a consequence of an additive toxic effect. Increasing oxygen level by aeration is sufficient to reduce acute ammonia toxicity under certain situations (Wajsbrot et al., 1991).

CONCLUSIONS

Appropriate water quality is essential for good results in aquaculture. Poor water quality reduces growth and affects health of fish. Therefore, reliable information about water quality in fish ponds is crucial for proper management in aquaculture. Modern systems for water quality monitoring allow measurement of many water quality indicators in real time. Those systems allow measuring of both seasonal and diurnal water quality dynamics. However, high market prices of these systems are still an obstacle for their mass usage in fish farming.

Any kind of changes in pond environment can be stressful to the fish, so parameters of the water are essential for obtaining maximum yield in a fish pond. Good water quality is characterized by adequate oxygen, proper temperature, transparency, limited levels of metabolites and other environmental factors affecting fish culture (Bhatnagar and Devi, 2013). Even with the new approach regarding conditions of water in ponds, fish mortality is still a present problem, which seeks better monitoring measures applied continuously. As a part of monitoring measures in fish ponds, collected data from water quality analyses should be recorded and stored for future reference. Problems in aquaculture can be avoided by responsible monitoring system.

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