Importance of water pH and hardness on fish biological processes

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***Abstract*: The success of any aquaculture depends heavily on the quality of the water. The quality of the water largely determines the success or failure of the aquaculture operation. Optimal water quality is considered necessary for any aquaculture operation, as it affects the productivity of the production system. The role of major abiotic factors, such as pH and water hardness, in the biological processes of fish, such as growth, survival, reproductive performance and embryology, has been discussed in this review.**

***Keywords*: ph, Hardness, growth, performance**

Introduction:
Water quality is an integral part of any aquaculture system. It plays an important role in fish health and any deterioration in water quality causes fish stress, eventually leading to disease (Arulampalam et al., 1998). Physical and chemical characteristics such as suspended solids, temperature, dissolved gases, pH, nutrients and the potential risk of toxic elements must be considered for successful fish farming (Johnson, 1995). Each water quality factor interacts and influences the other parameters, sometimes in a complex way (Joseph et al., 1993). Optimal water quality is considered a prerequisite for survival and growth, as it affects all life processes of fish (Bolorunduro and Abdullah, 1996. Boeuf et al., 1999). Among the various ecological determining factors are pH, hardness, temperature and salinity, which is perceived through receptors that can directly influence fish growth (Makori et al. 2017). On the other hand, limiting factors such as oxygen, ammonia, pH and hardness alter growth performance if their levels are above or below optimal levels (Boeuf and Payan, 2001, Menni et al., 1996 Mazerolle & Desrochers, 2005. Lacoul & Freedman, 2006). The aim of this article is to analyze current knowledge on the influence of pH and water hardness in fish.

Material and methods:
To obtain the water hardness you need: Ammonia solution disodium EDTA, eriochrome black T, sodium chloride, calcium carbonate, sodium hydroxide and ammonium chloride Calculation of the water hardness has been requested. The determination of the total water hardness is based on a complexometric titration of calcium and magnesium with an aqueous solution of the disodium salt of EDTA at pH 10. The determination of calcium in the presence of magnesium is based on the same principle, but at a value of pH of 12. In this condition, the magnesium ions precipitate as hydroxide and do not interfere with the determination of calcium. The magnesium present in the sample can be calculated by subtracting the volume of EDTA solution necessary for the determination of calcium from the volume required for the determination of the total hardness for the same volume of the sample.
Hardness is mainly caused by the dissolved mineral compounds calcium and magnesium, although minor contributions to hardness will also come from other ions, including iron and manganese. The amount of hardness is expressed in milligrams per liter (mg / L) or grains per gallon (gpg) as calcium carbonate. Hardness is calculated from the equation Hardness = 2.497 (Ca) + 4.118 (Mg). Therefore, fluctuations in magnesium reserve affect hardness more than fluctuations in calcium.

As for the pH There are two methods involved in the determination of pH value of water. They are:
1) Colorimetric Method
2) Electrometric Method
In environmental engineering experiments, each stage of water treatment depends on the pH value of the water. For example, coagulation, disinfection, corrosion control, acid-base neutralization and water precipitation.
The equipment needed to determine the pH of the water include: pH meter suitable for field and laboratory analysis. This can have one or two electrodes. Distilled water and standard buffers with pH 4, 7 and 10. Known standard solutions can be used. Thermometer capable of reading 77 ± 18oC to the nearest value of 0.1 degrees Celsius. Glass stirrer. Minimum capacity scale to read up to 1.1 lbs.
The procedure for determining the pH of the water involves the following steps:
The water sample is mixed and shaken properly with a glass rod. Using a watch glass, add a sample of water equivalent to 40 ml (5 ml more or less) to the beaker. The water temperature is allowed to stabilize by placing the sample holder for 1 hour. In the meantime, it can be removed. After 1 hour the water temperature is measured and this temperature is adjusted on the pH meter. Therefore, the pH meter shows a temperature similar to that of the sample. All these apparatus adjustments must be made and repaired prior to testing. There are some pH meters with automatic temperature controls. In such cases, the manufacturer's instructions should be followed. Standard solutions are used to standardize the pH meter. Here, too, the temperature is regulated as mentioned above. The electrodes are then inserted into the water sample. The glass is rotated and adjusted so that there is good contact between the electrodes and the water. Before starting the reading, the electrodes must be immersed in the solution for more than 30 seconds. This period of time is necessary for the correct stabilization of the meter to have a correct reading. On the pH meter equipped with an automatic reading system, a signal will be provided to indicate that the meter is stabilized. Once the reading

is displayed, it should be read to the nearest tenth of the entire number. If the value is displayed in the hundredth place, it must be rounded. The tenth digit is left if the hundredth digit is less than 5. For values greater than 5 after the decimal point, round to 1 unit. If the hundredth place equals 5, the nearest even number is taken as the rounded value. The appliance must be serviced after each use. The electrodes used are washed thoroughly with distilled water. If there is a film around the electrodes, they need to be cleaned. Cleaning the electrodes should be avoided as this will result in polarization resulting in slow response from the experiment.

Results and discussion:

Water hardness of the aquatic environment

Water hardness is defined as the measure of all divalent cations, especially calcium and magnesium. It is considered an important factor influencing aquaculture. It is generally expressed as mg / L of calcium carbonate (CaCO3). The hardness of the aquatic environment increases due to leaching from sedimentary rock, which contains sources of divalent cations, such as limestone and gypsum (Boyd 1979). Water hardness is often divided into two categories; permanent and temporary. Temporary hardness is the carbonate and bicarbonate part of calcium and magnesium salts, such as CaCO3, and permanent hardness is due to calcium and magnesium sulfates and chlorides (Boyd 1979). Water hardness has been shown to have a direct effect on the swelling of newly fertilized eggs, which is hypothesized to be an important process during early teleost egg development (Spade and Bristow, 1999). In general, calcium is of greater importance than magnesium in water management for aquaculture, as it is necessary for hardening the water of freshly fertilized fish eggs and for calcification of the skeletal structure of fish. larvae. . Calcium also affects membrane permeability, which is essential for successful embryonic development. The acceptable range of hardness in aquaculture is 50-150 ppm. (Tucker and Steeby, 1993).

Effect of water hardness on growth and survival

Water hardness in the range of 50-150mgl-1 CaCO3 is considered desirable, but the most preferable is above 100mgl-1 CaCO3 (Swingle, 1997; Molokwu and Okpokwasili, 2002; Stone and Thomforde, 2004). Bhatnagar et al., 2004 made similar observations which observed that a hardness of 75-150mgl-1 is optimal for fish farming, more than> 300mgl-1 of CaCO3 is lethal to fish and a hardness of less than 20 ml-1 causes stress. fishing due to the lack of nutrient availability in the water. Research by Milad and Seyed, 2011, reported the highest survival of Pterophyllum scalare juveniles with a water hardness of 100mgl-1 CaCO3. The water hardness of 80-91 mgl-1 of CaCO3 is considered optimal for the breeding of Clarias magur (Mesiar, 2018). Similar results have been reported in Rhamdia quelen (Townsend, 2003) and Ictalurus punctatus (Perschbacher, 1999).

Effect of water hardness on embryology

Natural calcium is needed for the "water retention" of fresh-laid fish eggs and to calculate the bone structure of the larvae. Calcium also contributes to the lining of the membranes and is considered important for successful fetal growth, especially in low-pH water or low ionic energy (Alderdice, 1988). Although few data are available, it seems that the growth of eggs and caterpillars in most freshwater fish is much better if the concentration of calcium is greater than about 5-10 mgl-1. The efficacy of extracting brown trout eggs (*Salmo trutta*) placed at pH 4.5 was very high if the water contained at least 10 mgl-1 of calcium (calcium 25 mgl-1 hardness as CaCO3). Chung et al., 1980 found that soft water was reported to cause premature hatching of carp (silver and larger) eggs and low larvae survival. The effect of water hardness on fish survival and selection of water hardness varies in oviparous and ovo-viviparous aquarium fish (Lee and Hu, 1983; Gonzal et al., 1987).

Effect of water hardness on reproductive performance

There is no direct evidence that demand for calcium from the environment is increased before and during, during the breeding season. Plasma calcium concentration increases over the period of oogenesis (e.g. Whitehead et al., 1978; Scott et al., 1980), resulting in the synthesis of yolk proteins as calcium complexes. It is possible that this temporary increase was due to redistribution between internal and external computers. However, the recovery of calcium from the central region may be significant. The acquisition of calcium from the center by freshwater fish is most likely due to the active transport outside the intestines (Sayer et al., 1991). Although calcium saturation can be stimulated by low calcium media (Perry and Wood, 1985; Flik et al., 1986), low pH water (Hobe et al., 1984; Reader and Morris, 1988) or without iron (Reader and Morris, 1988 Sayer et al., 1991), can prevent calcium ingestion or promote efflux, a simple path that leads to calcium loss. At a stage where increased plasma calcium supplementation is essential for successful production, branchial calcium loss should be extremely dangerous. Calcium ions are essential for storing vitellogenin in solution (Whitehead et al., 1978) during its transfer to the uterus and its incorporation into developing oocytes (Mount et al., 1988)

The pH of an aquatic environment

The pH value reflects the magnitude of the acidic or basic water content. They are described as bad logarithms of hydrogen ion concentration. The pH is expressed on a scale of 1 to 14. Conditions become more acidic as the pH level decreases and is basic as the value increases. Exposure to an aquatic animal pH is depressing or fatal, but the indirect effects of pH and the interaction of pH with other mutations are often more important in aquaculture than the direct toxic effects Doudoroff, 1956). The ideal pH for the growth and well-being of many freshwater aquatic animals ranges from 6.5 to 9.0 (Zaniboni-Filho et al., 2002). A number of studies have shown the importance of water pH in the first months of life, fish mortality and disease and its effects on growth and reproduction, a dangerous pH of growing media can lead to many deaths in fish culture (Doudoroff 1956; Kwain 1975; Jezierska and Witeska 1995; Zaniboni-Filho et al., 2002; Scott et al., 2005; Zaniboni-Filho et al., 2009; Nchedo and Chijioke, 2012). Inorganic water content with certain properties is common in acidic sensitive areas has been shown to have a low concentration. In equilibrium and carbon dioxide in the atmosphere they will have a pH of about 5.6, if the density of the moisture content is low and the anthropogenic acid inputs are not present.

Effect of water pH on growth and survival

Various physiological functions are regulated by water pH and when fish are exposed to high or high acidity, gion ionic balance decreases, eventually leading to very high mortality (Lloyd and Jordan, 1964; Alabaster and Lloyd, 1980; Freda and McDonald, 1988; ; Mcgeer and Eddy, 1998). At a pH below 6.0 or above 9.0, their greatest decrease in the growth activity of most fish species (Parra and Baldisserotto, 2007). Any change in pH, above or below the right level can affect the body's function or body function such as growth function, reproductive system and environmental distribution (Boyd, 1998; Zweig et al., 1999). In fish, low pH exposure has been shown to have a negative impact on growth or no effect (Mount 1973; Leivestad et al., 1976; Menendez 1976; Jacobsen 1977). At an acidic pH of 5.5, reduced growth was observed in various fish (Menendez, 1976; Craig and Baksi, 1977, Ndubuisi et al., 2015).

Effect of water pH on embryology

Failure to fertilize eggs and increased fetal death were observed in water pH below 4.0 Salar salar (Carrick, 1979; Daye and Glebe, 1984; Peterson et al., 1980), Oncorhynchus nerka (Parker and McKeown, 1987; Zaniboni- Filho, 2000), Salvelinus fontinalis (Swarts et al., 1978) [89] and Cyprinus carpio (Korwin-Kossakonski, 1988). There is a significant decrease in the egg's ability to resist paralysis due to mechanical action as low pH leads to disruption of the osmotic activity of perivitelline colloids leading to reduced egg water absorption (Eddy and Talbot, 1983; Westernhagen, 1988). Increasedly low pH also inhibits the formation of the enzyme chorianase, which is responsible for the fertilization of fish eggs (Kelley, 1946; Westernhagen, 1988). Enzyme activity is mainly dependent on fish fish and water pH, the highest chorianase activity is observed at pH above 6.5 in trout rainbow eggs (Hagenmaier, 1974), between pH 7.5 and 8 e -Oncorhynchus keta (Bell et al., 1969). The pH of the incubation center also influences the stages of embryonic development, delayed development was noted in Clupea pallasii by Kelley, in 1946 and the same rapid development was observed at a higher pH in Danio rerio by Johansson et al., 1973. According to Johansson and Kihlstrom (1975) The larvae were affected by the size of the North pike eggs (Esox lucius), those eggs hatched under pH (pH 4.2) the larvae were smaller in size than the neutral pH. A study by Rutherfordmore by Menendez, 1976 states that a low pH of 5.0 leads to delayed absorption of a bag of yolk into brook trout. Similar observations were also reported by Nelson, 1982. Perivitelline fluid usually allows cations such as Na +, K +, Ca2 +, Mg2 +, and H + to enter under normal external and internal pH conditions, where these conditions they are good for salt-free water with a neutral pH. , and which severely damage acid sources (Alderdice, 1988).

Effect of water pH on reproductive performance

The larvae of many water taxa grow in direct contact with the external environment and are strongly influenced by environmental oppressors. PH is considered an important stressor that controls adverse effects on ion balance and thus affects the reproductive and functional success of natural people (Stumpp et al., 2012; Parker et al., 2009). Sensitivity to extreme pH conditions varies depending on fish species and age, fish that show low tolerance in the embryo and embryonic stages (Lloyd and Jordan, 1964). Ogenesis and reproductive failure have been reported in fish in acidic lakes, even in the presence of heavy metals (Almer, 1972; Beamish et al., 1975; Frenette and Dodson, 1984). Some species have reported that they cease to reproduce at higher pH levels than those in large fish (Beamish, 1976; Vuorinen et al., 1992). Fertility may fail due to inability to produce and / or release an egg or sperm if a gamete is released resulting in an unsuccessful fertilization. Reproductive capacity can be measured by measuring the size of the gonad before birth. The raw material for gonadal maturation in fish is provided by the gonadosomatic index (GSI), which actually represents the gonad's body weight. The GSI concentrations of the female perch (Perca fluviatilis) taken full time were significantly lower in fish from the acid lake (pH 5.1-5.2) than those from the circumneutral lake (pH 6.6) (Valtonen and Laitinen, 1988). cannot be calculated with low pH alone, however, as there was a significant difference between concentrations of calcium in water (53 and 106 μmol l -1 respectively). In contrast, Vuorinen et al., 1992 reported higher GSI levels of GSI in acidified pools (pH 4.3-4.8) than in circumneutral pools (5.9-6.4) with slight variations in water calcium filtration (10-40 and -60-70 μmol -1 respectively). GSI retrieval as an indicator of reproductive power that does not provide specific details about gamete numbers or status. In addition, oocyte atresia has also been observed in brook trout (Salvelinus fontanalis, Salmonidae) expressed at pH 4.5, and in very high water pH 9.5 (Tam and Payson, 1986; Tam et al., 1990). In a separate study from brook trout, a woman subjected to artificial acid, medium water containing aluminum (pH 5.0; [Ca] 12.5 μmol l-1; [Al] a total value of 8.0 μmol l-1) had a higher value of -GSI after childbirth than other animals that have been kept in poor condition (Mount et al., 1988).

Conclusion

It is clear from this brief discussion that pH and hardness play an important role in the body's behavior and production of fish. Therefore, more research needs to be done in this field to better understand these parameters of abiotic water quality.

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