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Review Article

Aqua cultural attributes of some water physicochemical parameters: A review

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Abstract: Water quality is essential for successful aquaculture development. Anthropogenic activities mostly as a result of industrial and agricultural activities are the major sources of water pollution in an aquatic environment. Interaction of various physical and chemical parameters of water attributed to the distribution, composition and abundance of aquatic organisms and their relationship with abiotic component of the water environment. Fish general well-being is positively correlated with water quality and longtime exposure of fish to water pollutants may interfere with normal growth and reproduction and sometimes lead to the dead of fish. Routine measurement of the major water physicochemical properties is highly needed for the general welfare of fish and for the growth of aquaculture industry.
Keywords: Water quality, aquaculture, Physicochemical, Pollution.

INTRODUCTION

Water is regarded as a universal and the most important solvent needed to the existence of all living organisms including man [1, 2]. It is an important natural resource required for human settlement patterns, agricultural as well as industrial activities [3]. Unfortunately in wealth-generating activities, water becomes a sink for dumping of waste materials which deteriorates its desired purposes [4]. Small and medium scale industries and agricultural activities contributed a lot to wastes generation and disposal in aquatic environment [5]. Interactions of physical and chemical properties of water contributed to the composition, distribution and abundance of aquatic organisms, it is also gives an insight in to the relationship between organisms and their environment and can be used to determine water quality and productivity of the water body [6]. Physicochemical attributes of water would assist in discovering the design and function of water environment to its living organisms. Availability of certain chemical elements in water may result to an effect to biotic component of the water [7]. Appropriate equilibrium of physical, chemical well as biological components of a water body is a vital requirement for a successful fish production and therefore occurrence or absence of a given element in an aquatic habitat can be a determining factor in the general productivity of that water body, it could also determine the category of living organisms that might be presence in the water body [8]. [9] reported that high amount of silica in a water favours high diatoms population, whereas high species diversity of snails might be related to availability of calcium in a said water body.

Water with high quality is needed to the entire life of fish as it provides the necessary requirement for the welfare of fish such as reproduction, breathing, feeding and growth [10]. Stable water quality is necessary in maintaining the biodiversity of aquatic animals including fish, impairment of the water quality can causes decline in fish production or even make it impossible [11]. Fish general wellbeing is strongly related to the water quality of an aquatic environment [12]. Long period exposure of aquatic organisms to environmental pollutants with possible effects on growth and reproduction are important considerations of fish farmers [13].

Temperature

Temperature is an important physical parameter in an aquatic environment because many biological and chemical processes are temperature dependent. It is one of the environmental conditions affecting fish growth and survival [14, 15]. When water temperature increases, the evaporation and volitization of chemical substances also increases, but conversely the solubility of gases such as oxygen decrease [6]. Temperature is the most easily and frequently measured field parameter but cannot provide detailed information on the general health status of aquatic system; it can only give the early signal on other water parameters. When the water temperature is high, the respiration rate of aquatic animals increases, also the decomposition of organic matter that required oxygen [11, 16]. Temperature of the water affects the general well-being of fish in aquatic environment; changes in water temperature affect food abundance in water and changes in the entire growth pattern of fish and later cause the migration of fish within the water column. Sudden increase in water temperature can results to increase in respiratory metabolism and also increased maintenance strategy and rapid weight loss, but sometimes increase in temperature can increase fish feeding rate, digestion and feed conversion efficiency [17]. Temperature affects the oxygen availability of water, rate of hydrophytes photosynthesis, body metabolism of aquatic animals; and the sensitivity of organisms to toxic waste, parasites and diseases [29].

Fish are exposed to many stresses, this is because fish body temperature differs with ambient temperature as a results of ectothermic behavior which affect their general body physiology and therefore cannot dissipate extra body heat through perspiration but do so by movement between locations with different water temperatures to obtain optimal temperature for their survival [18]. Different fish species required different optimal temperature ranges for normal activities and body metabolism such as feeding, swimming, growth and reproduction [19, 20].

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important indicator of water quality in any aquatic environment, large proportion of aquatic organisms obtain oxygen directly from the water instead of gasping from atmosphere[11]. Dissolved oxygen concentration in water can give detailed information on the health status of the water body; this is because most aquatic organisms can live and grow only when the dissolved oxygen concentration is favorable [21]. Any reduction in dissolved oxygen level outside the optimum condition of a particular fish species would result to fish stress [6]. Dissolved oxygen level and sometimes fish stocking density are among major pre-requisite for a successful aquaculture development [22]. Fish required oxygen just like terrestrial organisms in order to maintain normal body metabolism, movement, feeding and biosynthesis, oxygen availability in water is highly limited as compared to atmosphere where there is abundant oxygen and fish can get oxygen from water through gill surface area only and it is so narrowed in most fish species [23]. Dissolved oxygen content in water can affect fish growth pattern as well as feed utilization efficiency, lower fish growth rate correlated positively with lower dissolved oxygen concentration and fish feed conversion efficiency is higher under high dissolved oxygen concentration [24, 22]. Growth pattern of Nile tilapia was greatly decreased due to low dissolved oxygen availability [25].The need for oxygen for any aquatic organism is obvious. Aquatic organisms react to the quantity of dissolved oxygen available, low dissolved oxygen may be a limiting factor, but the fish may survive if previously acclimatized to low oxygen. Dissolved oxygen always act interactively with other factors such as temperature and pH [26, 27].

Dissolved oxygen in water environment is one of the most important components of aquatic systems, it is required for the metabolism of aerobic organisms, and it influences inorganic chemical reactions. Oxygen is often used as an indicator of water quality, high oxygen concentration usually indicate good water quality [28]. Oxygen enters water through diffusion across the water surface, by rapid movement such as waterfalls or riffles in streams (aeration) or as a by-product of photosynthesis by aquatic plants [29]. In general, the concentration of dissolved oxygen will be the result of biological activity within the water column. Photosynthesis by aquatic plants will increase the DO during day light and the DO levels will fall during the night time. In natural waters, man-made contamination, or natural organic material will be consumed by microorganisms [30]. A condition of low oxygen level in a water environment is regarded as hypoxia, it occurs in all water bodies in the world receiving high nutrients load due to anthropogenic activities [31], which causes reduced respiration rate, reduced growth rate and sometimes even death of aquatic animals depending on the species sensitivity as fish is more sensitive compared to crustaceans, annelids and bivalves [32].

Transparency

Transparency is the opposite of turbidity which is a measure of water clarity, the less materials suspended in water the higher light can penetrate through it and the higher the transparency [6]. Heavy rainfall in the tropic, mostly after a long period of drought, results in washing of soils, debris, and nutrients in to the aquatic environment such as rivers, streams, lakes, ponds and seas, thereby reducing the transparency of the water, but the traces of nutrients sometimes increases the water productivity, but when exceed the required level may resulted to eutrophication which is an excessive growth of algae in aquatic environment [33]. The inverse relationship between water clarity and rainfall might be attributed to increased allochtonous organic matter brought by flooding during the rainy season [34, 8].

Suspended materials include soil particles, algae, plankton, microbes, and other substances are the major causes of higher turbidity in most aquatic environment, increase in water turbidity can raises water temperature; because the suspended particles absorb more heat and this in turn reduces the concentration of dissolved oxygen (DO), warmer water holds less dissolve oxygen than cold water[35]. Water transparency reduces production of natural food in water [36].

Hydrogen ion Concentration (pH)

The pH of water is a measure of hydrogen ion that causes acidity and alkalinity on a scale of 0-14 with 7 being the neutral state [37]. It is been used universally to express the intensity of the acid or alkaline condition of a solution [38]. Very low and high pH levels may reduce reproduction in fish, sometimes associated with death [6]. Acidity and alkalinity death points are approximately at pH 4 and 11 respectively, pH values ranging from 6.5-9.0 are observed to be most suitable for fish production [39]. The pH of an aquatic ecosystem is important because it is closely linked to biological productivity, although the tolerance of individual species varies, pH values between 6.5 and 8.5 usually indicate good water quality [40]. Most vertebrates including fish have mean blood pH of 7.4, and therefore a similar water pH of around 7.0 to 8.0 is required for normal fish metabolism, fish might be under stress if the water pH is too acidic (below 5) or when it is too alkaline (above 10) [40]. Respiration by aquatic plants affect daily water pH fluctuation, during the day time there is enough dissolved oxygen due to photosynthesis and the dissolved oxygen concentration decline after sunset [41].

Alkalinity

Alkalinity refers to ability of aqueous media to interact with the hydrogen ions available [38], in respect to water, alkalinity is occurring due to the presence of carbonate, bicarbonate or hydroxide compounds in water such as magnesium, calcium, sodium and potassium [42]. Alkalinity is a related concept that is commonly used to indicate a system's capacity to buffer against acid impacts and buffering capacity is the ability of water to resist or dampen changes in pH [28]. It is also an index of productive ability of the water [37]. Measuring alkalinity is important in determining a water body's ability to neutralize acid pollution from rainfall or waste water. Alkalinity is influenced by rocks and salty industrial waste water discharge [29]. An average freshwater alkalinity value is 150 mg/L and observed ranges are between 5-250 mg/L [43]. Alkalinity is a bye product of bicarbonate and carbonate after dissolution of limestone, calcium silicate or feldspars, when water pH is below 4.5; the bicarbonate is absent [44]. Low concentrations of alkalinity due to water acidity or hardness are not suitable for fish survival as it's impair with the hatching of the fish eggs, this is because most fish species hatch their eggs at an optimal pH condition mostly around the neutral pH [45]. Alkalinity of water is very crucial because photosynthetic activity of aquatic organisms during the day time can raise the pH to be too alkaline in a low-alkalinity and poorly buffered waters [45].

Phosphorous

Phosphorus is regarded as one of the most essential nutrients limiting the growth of autotrophic organism which are the primary producers and source of nutrients in an aquatic system [46]. It occurs solely as phosphate in both natural as well as wastewater [47]. In tropical water bodies, phosphorous is limited in supply and any slight increase in phosphorous supply can alter the nutrient supply in water, these include excessive plants growth, algal bloom, decrease in dissolved oxygen content and dead of aquatic animals including fish [47, 48, 49]. Phosphorous also contributed to the existence of all living organisms, this is because cellular phosphate compounds gets energy generated from food consumed and transform it to normal body activities including locomotion, reproduction and growth [50]. Phosphorous occurs solely as phosphate in a natural aquatic environment most of which dissolve and the remaining suspended one can increases water turbidity and alter the water quality [50]. Phosphorous is among the limiting nutrients in natural water body this is due to the fact that it's occurs in very low concentration and it is been quickly taken up by aquatic plants [11].

Nitrogen

Nitrogen is vital source of nutrients for both aquatic plants and animals, this is due to its contribution in the formation of major constituents of protein [51]. Nitrogen occurs in aquatic environment in both organic and inorganic forms and the availability of each form is primarily determined by biological activity [26]. Nitrogen-fixation due to activities of blue-green algae (cyanobacteria) and some species of bacteria that converts dissolved molecular N_2 to ammonium (NH_4^+). Aerobic bacteria convert NH_4^+ to nitrate (NO_3-) and nitrite (NO_2-) through nitrification, and anaerobic or facultative bacteria convert NO_3- and NO_2- to N2 gas through the process of denitrification [38, 35]. Primary producers assimilate inorganic N as NH_4+ and NO_3-, and organic N is returned to the inorganic nutrient pool through bacterial decomposition and excretion of NH4+ and amino acids by living organisms [52]. Nitrogen is the most limiting nutrient of algae growth, consisting one to ten percent (1-10%) of dry weight of algae [4]. Surface run-off mostly from agricultural farmlands as a result of agricultural fertilizers waste, house hold waste, conversion of nitrite to nitrate due to oxidation of nitrogenous ammonia and domestic waste are the major sources of nitrogen to aquatic environment [37]. Excretion by aquatic animals in a cage culture in rivers, streams and lakes is also contributing in generating excess nitrogen in to natural aquatic habitat [53].

Electrical conductivity

Conductivity is the measure of water ability to convey electric current, and therefore electrical conductivity of water is directly proportional to its dissolved mineral matter content [38]. Conductance increases due to increase in total salt concentration in the water; conductivity is measured in Siemen per centimeter [11]. Most freshwater environments have conductivity values ranging between 10 and 100 µs/cm which approximately equivalent to 5 to 700 TDS/L. High conductivity in water is indicating the presence of huge quantity of dissolved salts which may harm the fish species in the water environment [54]. Suspended particles influences ion availability in water mostly through absorption and desorption effects of the ions found on the surface of suspended matter [55]. Water conductivity depends on the availability of cations and anions in the water, mobility and valence of the ions and sometimes also on the temperature of the water [2].

Ammonia

Ammonia is a form of nitrogen been readily used by aquatic plants, it is an important source of nutrient for phytoplankton; it is also the major end-product of protein catabolism excreted by aquatic animals [11]. Temperature and pH of water are important parameters in determining the content of total ammonia occurring in un- ionized form, a pH increase of 1 unit brings about ten-fold increase in the content of un-ionized ammonia [51]. Increase in ammonia content of water is related to poor fish growth, increase in fish vulnerability to diseases and finally the death of the fish [26]. Ammonia is released in to water after decomposition of organic matter and excretion from aquatic animals [46].

CONCLUSION

Physicochemical properties of water are regarded as a good indicator of water quality. Different fish species have different required optimum range for all the physicochemical parameters in which fish body metabolism can be affected when the value of a particular parameter is not suitable for their normal growth and development. Effluent from agriculture, industry and domestic waste need to be treated before discharging in to the aquatic environment so as to minimize the occurrence of pollution and to have a sound aquaculture production.

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