Fish Pond Water Quality

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The spread of disease caused by the presence of bacteria, algae, protozoa, and fungi in a fish pond can cause biological pollution and reduce fish product production. Water can quickly lose its ability to support life, reproduction, waste excretion, growth, and feed the fish in fish ponds. The needs of the fish, the water quality, and factors for managing the water quality should be understood by those wishing to be successful fish farmers.

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1. Water Pollution in the Fish Pond

The spread of disease caused by the presence of bacteria, algae, protozoa, and fungi in a fish pond can cause biological pollution and reduce fish product production. Winfield and Gerdeaux [1] say the fish infections were caused by primary pathogens such as Coliform bacteria and *E. coli*.

Fecal Coliform Bacteria: The bacteria causing different diseases in fish are grouped under Coliform bacteria (Gregor [2]). Their concentration is dangerously high in those fish ponds receiving animal waste or human waste from wildlife and septic systems, according to Garcia and Beıcares [3]. Coliform bacteria may also be introduced into small ponds by a large number of waterfowl, according to Burhanettin et al. [4]. A water test for fecal coliform bacteria can identify their presence and number of colonies per liter (Cho [5]). Only certified laboratories are recommended for this test. A concentration of less than ten bacteria per 100 mL of water is the optimum condition for fish farms (Annie et al. [6]).

E. coli: *E. coli* is a more dangerous group of bacteria than coliform bacteria (Salamon et al. [7]). *E. coli* is fatal in small quantities, and the pond used for fish production must be *E. coli* free as their presence spreads serious disease and causes death (Apha [8]). Water tests are required for *E. coli* to identify their presence in respective ponds (Witte [9]).

Eutrophication: Excessive plant growth resulting from nutrient enrichment due to human activity is known as eutrophication. Some authors reported that eutrophication favored fish growth. Recent studies conclude that growth patterns with density dependence were more complex than once thought. The uncontrolled growth of algae or cyno-bacteria in fish ponds harms fish production and their habitat. Its impact is explained by Winfield J. and Gerdeaux D. [1], in which they give an example of fish death due to eutrophication in England and Scotland. Fish abundance and functional composition are directly related to the level of eutrophication. With the contribution of some fish species to the process, researchers succeeded in combating eutrophication or reoligotrophication through falling nutrient levels and re-gaining the original level (Asim et al. [10]).

Acidification: All scientists studying ecology agree that acidification due to various reasons negatively affects the water ecosystem, especially the freshwater ecosystem. Acid is the major contributor to the acidification of fish ponds. Massive damage to the S. *trutta* population in England and Scotland was documented. This research inspired a large-scale program to resolve this problem. Following this research, the recovery of water quality was reported, and S. *trutta* populations also recovered, as per Asim et al. [11].

PH: PH is the measure of water acidity. The PH value of pond water has significant importance in fish culturing (Berg and Fiksdal [12]).

Chemical Pollution: Chemical pollution is the same as acidification, though within a restricted distribution area. Industry plays a significant role in increasing environmental chemical pollution. Chemical pollution is dangerous and causes disease because the population has not developed immunity against chemicals (Hossain [13]. In the latter half of the 20th century, the major environmental problem received significant research attention showing that widespread pollution greatly affected fish production.

Pesticides and Herbicides: Used to control plant and algae growth, pesticides and herbicides introduced into the surrounding area contaminate the fish pond. (Waterfowl death and animal sickness are caused, and pesticide pollution kills fish) as per Schindler [14]. Heavy rain and wind following pesticide application to a nearby field may aid the pesticide in reaching the fish pond (Holopainen and Oikari [15]). The use of herbicides in the fish pond meant to control plants and algae must follow the herbicide's label instructions (Michael et al. [16]). For irrigation purposes, pesticides used in water cause plant injury and damages the population badly, as the fish are not immune to the chemicals (Annett [17]).

Hardness and Metals: Water hardness is caused by the presence of magnesium and calcium in the water (Engel [18]). For fish, water hardness is not dangerous. Pond water in limestone areas is commonly hard (Wilde et al. [19]). In controlling pond plants and algae, the effect of herbicides used can be spoiled at a hardness above 50 m^2/L (Clarke [20]), and the efficiency of copper-based pesticides can be reduced (Ahmad et al. [21]). An offensive taste develops in the inhabiting animals and aquatic environments contaminated with copper, manganese, and iron (Aboul-Ezz and Abdel-Razek [22]). In fish ponds located in coal mining areas, the concentration of iron and manganese is high (Waqar [23]). The pond's aesthetic can be changed but did not cause disease in fish by these metals (Oguzie [24]). Above 0.3 mg/L, due to a high concentration of iron, orange precipitation may occur in the pond. Using copper-based herbicides for plant control in fish ponds with above 1 mg/L copper concentration can cause an offensive metallic taste (Norman [25]).

2. Water Quality in a Fish Pond

Water can quickly lose its ability to support life, reproduction, waste excretion, growth, and feed the fish in fish ponds. The needs of the fish, the water quality, and factors for managing the water quality should be understood by those wishing to be successful fish farmers. In filling their fish ponds with water, farmers should pay attention to chemical and physical aspects (Lucy [26]; Water Pollution Facts [27]; Groundwater [28]).

Temperature: Feeding, growth, and reproduction can affect fish welfare, and controlling the temperature is very important. Purdue University says that for each −7.8 °C rise in temperature, the metabolic rates in fish will double. Optimal fish growth varies depending on its optimal average temperature range; on whether the fish is cold-water, cool water, or warm water, and the temperature of the water depends on the availability of the fish selected for the pond. The optimal temperature range for the growth of cold-water trout and salmon is between 09–18 °C. Catfish and tilapia are warm-water fish that prefer temperatures between 24–27 °C, while yellow perch are cool-water species that prefer between 15 °C and 30 °C (EPA [29]; Ezugwu et al. [30]).

Suspended solids: Recirculating aquaculture systems cause water problems related to clay suspended particles, along with plankton, fish wastes, and uneaten feed. In these systems, up to 70 percent of the fish waste nitrogen load may contain particles representing a major source of irritation to fish gills. Fish, as a rule, produce one pound of waste per each pound of body weight (Ahmed et al. [31]; Cloete et al. [32]; Theofanis P. Lambrou et al. [33]).

Photosynthesis: Photosynthesis is the process by which food source carbon dioxide is converted. As a byproduct, and using sunlight, the oxygen is released into phytoplankton. In fish ponds, nitrogenous wastes such as ammonia, nitrates, and urea remove several forms of photosynthesis. The greatest concentrations of the photosynthetic process, driven by oxygen occurent sunlight, usually occur from 2–3 pm. Phytoplankton are primary respirators. At night photosynthesis ceases (EPA [29]; Brands et al. [34]; Loganathan et al. [35]; Geetha and Gouthami [36]; Abba et al. [37]).

Dissolved Oxygen: Directly or indirectly, dissolved oxygen (DO) is the most important chemical parameter in aquaculture. Low-dissolved oxygen levels are responsible for more fish deaths than all other problems combined. As it is with human respiration, fish require oxygen. The activity level, size, feeding rate, and temperature of the fish affect the amount of oxygen it requires. Lewis et al. [38] determined that, per day, striped bass consumed 0.012–0.020 pounds per pound at 25 °C. A temperature increase for each −7.8 °C, which doubles the metabolic rate of a striped bass, may be due to the higher oxygen requirement. Concerning increases in altitudes at higher temperatures, decreases, and salinities, **Table 1** depicts the DO amount in water in which the water decreases the amount of oxygen that can be dissolved.

Table 1. DO amount in water.

Variable	Temperature (°C)				
	19	**21**	**23**	**28**	**31**
Salinity (ppm)					
0	**9.4**	**9.1**	**8.7**	**7.9**	**7.5**

Variable	Temperature (°C)				
5000	8.9	8.6	8.3	7.5	7.2
10,000	8.5	8.2	7.9	7.1	6.8
altitude (m)					
0 (Sea Level)	9.4	9.1	8.7	7.9	7.5
305	9.0	8.7	8.4	7.6	7.3
610	8.7	8.4	8.1	7.3	7.0

CO_2:CO_2 originates from limestone-bearing rock in water sources or photosynthesis. Fish can tolerate dissolved oxygen concentrations of 10 ppm. Good water supporting a carbon dioxide-free environment for fish inhabitants normally contains less than 5 ppm. From noon to daybreak at 5:15 a.m. in an intensive pond fish culture, carbon dioxide levels in water may fluctuate (Pule et al. [39]; Adu-Manu et al. [40]).

Nitrogen: Dissolved gases, especially nitrogen, are usually measured in terms of “percent saturation”. The water normally holds the amount of gas saturation at a given temperature. A gas above 110% supersaturation level is usually considered problematic.

Ammonia: As wastes enter the water, the amount of urea and fish excretion ammonia lessens. The ionized and un-ionized ammonia in aquaculture systems occur in two forms. The ionized form (NH4+) is not toxic ammonia. NH3 is very toxic in un-ionized form. Both forms of “total ammonia” are grouped. To harmless nitrates, toxic ammonia can be degraded through biological processes. **Table 2** depicts a pH increase as temperature un-ionized ammonia levels rise.

Table 2. un-ionized ammonia levels.

pH	15 °C	20 °C	25 °C	90 °C
7.0	0.25	0.4	0.6	1.0
7.4	0.6	1.0	1.5	2.4
7.8	1.6	2.5	4.0	5.7
8.2	4.1	5.9	10.0	13.2
8.6	8.4	13.7	20.7	27.7
9.0	19.6	28.5	39.1	49.0
9.2	38.3	50.0	61.7	70.8
9.6	60.2	71.2	79.4	85.9
10.0	72.4	79.9	85.6	90.6

3. Water Quality Index (WQI)

Drinking water to compute the WQI of USEPA and WHO recommend WQM parameters concerning different living conditions around the globe (Kashid et al. [41]; Chowdury et al. [42]; Kumar et al. [43]; Kawarkhe et al. [44]; Prasad et al. [45]). WQI parameters show that measuring water quality by traditional laboratory-based methods is commonly utilized.

Total coliform (TC): In soil, human and animal waste, etc., bacteria are usually present. Generally, humans and animal feces contain a class of TC belonging to the fecal coliforms. TC measuring methods commonly use minimal medium ONPG and multiple tube fermentation, numbering the most probable membrane filtration. Organisms/100 mL is its unit. The disease-causing pathogen is a signal to humans, but its presence in Coliform bacteria is usually harmless. Gastrointestinal upset and general flu-type symptoms (e.g., abdominal cramps, fever, and diarrhea) are commonly observed symptoms.

Fecal coliform (FC): Of total coliform, it is a subdivision. Escherichia coli (E-Coli) is the most common member. In humans and animals both warm and cold-blooded, bacteria exist in waste and intestines. Other pathogenic organisms may exist, but FC are not pathogenic by themselves. ONPG is a common method of measuring FC, recording the most probable number, membrane filtration, multiple tube fermentation, and minimal medium. Organisms per 100 mL number are its measuring unit.

Total dissolved solids (TDS): Magnesium, calcium, sodium, potassium cations, etc., present in the water represent soluble solids both organic and inorganic. A minimum threshold, if it increases, becomes saline beyond salinity because the water is highly correlated. Fertilizers, pesticides, sewage treatment, floodwater, etc., are the major sources. To measure it in mg/L, the gravimetric method is generally used.

Total suspended solids (TSS): In water, both organic and inorganic material suspended represents the number of remains. Light absorption is correlated. Let water absorbs less oxygen, and more light absorption may increase TSS. This may have adverse effects on aquatic life. In mg/L to measure it is generally utilized the gravimetric scheme.

Total solids (TS): Suspended solids represent the total amount of solids when water is dissolved. Sulfur, calcium, phosphorous, nitrate, iron, etc., are generally dissolved solids. Plankton, algae, silt, clay particles, etc., may be included. The aquatic plant process affects photosynthesis in turn; the passage of sunlight through water can affect water clarity. Retaining more heat may adversely affect aquatic life, and water will heat up due to this.

Total hardness (TH): For domestic or industrial applications, TH determines the suitability of water. In water, the presence of magnesium and calcium is the concentration. With an EDTA solution, it is generally measured using a titration method. In mg/L or parts per million (PPM), calcium carbonate ($CaCO_3$) hardness is given in terms of equivalent quantity. Magnesium and calcium are basic hard water minerals that can fulfill dietary needs, that may be beneficial for humans but are not harmful. The heated formation of calcium carbonate is the major drawback of hard water, leaving decay deposits on heating elements and pipes.

Dissolved oxygen (DO): In water, oxygen solubility is represented by DO gained from the atmosphere during photosynthesis or absorbed generally from the water. For aquatic life, it plays an essential role. It corrodes water pipes, but it may make water taste better for drinking. It is highly important for aquatic life. For example, aquatic life undergoes stress when its level falls below 5 mg/L. An electric meter or Winkler titration is generally utilized for measurement purposes.

Electrical conductivity (EC): EC represents water's ability to conduct electric current. Water's ionic content helps with measuring alkalinity, hardness, and some dissolved solids, though it is not involved directly. Measurement methods utilized are specifically electrical.

Chloride (Cl): Water is measured using the mg/L titration method (milligram per liter is naturally available). If 250 mg/L is a minimum threshold, exceeding it may make water taste saltier though the excess may not damage humans. For agricultural activities, excessive Cl may be harmful. Due to corrosiveness, the electrical conductivity of water increases, reacting due to soluble salts forming with metal ions in metallic pipes. This also raises the level of metals in water.

Temperature (T): T affects the chemistry of water. It increases at higher temperatures because of chemical reactions. At higher temperatures, groundwater especially can dissolve more minerals from rocks surrounding the water. Electrical conductivity will increase due to this act. Rates of gas transfer affect dissolved oxygen and have a great effect on aquatic life. It is often measured in Celsius.

Potential of hydrogen (pH): Normal water has a pH of 7. Alkalinity means a range from 8 to 14, while acidity indicates a value from 0 to 6. For humans, water with pH values from 6.5 to 8.5 is generally safe to drink [11]. Electrodes and electrometry are measured using pH. If corrosive and soft, then the water is acidic.

Oxidation-reduction potential (ORP): Also known as REDOX, it is a millivolt (mV) measurement to determine either reduction or oxidization substance capability. To measure ORP, an ORP meter is used. A positive reading means the substance is an oxidizer (i.e., acceptor of electrons). A negative reading means a reducer (i.e., donor of electrons). A high ORP generally having chlorine, it is added to water to kill unwanted bacteria and pathogens. Bacteria's DNA, and proteins from cell membrane oxidation, will attract electrons. In addition, it can disinfect water oxygen, which also has high ORP.

Total chlorine (T-Cl): This represents the levels of free and combined chlorine. To measure free chlorine and maintain residual levels, it is necessary to add appropriate solutions. To kill harmful microorganisms (e.g., viruses and bacteria), numerous municipalities intentionally add chlorine to water which, if ingested, could make us sick.

Free chlorine (F-Cl): Residual, chlorine residual, or residual chlorine is well known. Water level potability is indicated. As a dissolved gas, (Cl_2), hypochlorite ion (OCl^-), and/or hypochlorous acid (HOCl) is the amount of residual chlorine (RC) present in the water. A test kit can measure the total amount of Cl_2, OCL, and HOCL. The measurement unit is mg/L. It is generally used to disinfect contaminated water. In digital water colorimeters or color-wheel test kits, F-Cl is tested via pool test kits. Free from recontamination during storage and most disease-causing pathogens means water is protected from its presence.

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