iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IX **Month of publication:** September 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

Determination and Comparative Study of Water Quality Parameters in Shrimp Culture Ponds

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***Abstract:** Water quality is essential for any Aquaculture operation, because it affects reproduction, growth and survival of aquatic organisms. The present study is aimed to investigate important water quality parameters like $P^{H,,}$ salinity, dissolved oxygen, ammonia, hardness, and alkalinity n different shrimp culture ponds of Kota mandal, SPSR Nellore district, AP. Four villages Koduru, Gollapalem, Thupulupalem, Duggarajapatnam of Kota mandal were selected and 5 ponds in each village were estimated during the third month of the culture period. Water quality parameters of all shrimp culture ponds were estimated, Maximum growth and yield was achieved in Konduru Village ponds(Table:1) by maintaining good water quality compared to other villages(Tables:2,3&4)*
***Keywords:** Water quality, Aquaculture, salinity, Hardness.*

I. INTRODUCTION

Aquaculture can be defined as the high-density production of fish, shellfish and plant forms in a controlled environment. Stocking rates for high-density aquaculture are typically thousand fold greater than wild environments. Modern fish culturists employ both open and close systems to raise fish. Open systems, such as, the raceways are characterized by rapid turnover of water. Closed systems are commonplace in pond culture of carps, catfishes, tilapia, sea bass, prawn and shrimp among others. Closed aquaculture systems do not have rapid turnover of water, but do not have a high surface to volume ratio facilitating exchange of gases, nutrients, energy etc. with the surroundings. Such closed system, intensified, high-density aquaculture forms the basis of concern. The different forms of high density, intensive aquaculture is quite similar because they all obey the same set of physical and chemical principles. These principles compose the subject of water chemistry and its net result i.e. the water quality. Poor water chemistry leads to deteriorate water quality, which causes stress to the organisms being raised. Efficient feed conversion, growth and marketability of the final product cannot occur unless the pond system is balanced or in harmony with nature. Therefore the overriding concern of the fish culturist is to maintain, balance or equilibrium conditions with respect to water chemistry and its natural consequence, good water quality. Water quality for aqua culturists refers to the quality of water that enables successful propagation of the desired organisms.

A sufficient supply of good quality water is essential to any aquaculture operation. Water quality affects reproduction, growth, and survival of aquatic organisms. The criteria for good quality water vary with the kind of organisms and are established by safe levels, i.e., physical and chemical properties of water which have insignificant adverse effects on shrimp growth and survival. To keep water properties within safe levels, one must understand those processes so that the elements inhibiting prawn growth and survival can be detected and their impact minimized. The practice of semi-intensive and intensive culture systems usually results in pollution of the culture water from uneaten food and waste products of cultured organisms. Avnimelech and Lacher (1979) found that 35% of the organic carbon, 89% of the nitrogen, and 68% of the phosphorus from the feed are accumulated in the fish pond bottom. In an intensive culture system of *Penaeus monodon*, 80% of the nitrogen from feed remained in the ponds (Chen and Liu 1988). As organic materials and their derivatives accumulate and exceed safe levels, they become a liability to water quality maintenance. Therefore, water quality management is one of the most important culture practices, especially in semi-intensive and intensive culture systems. Production intensification is the trend in shrimp culture in Taiwan (Chien et al. 1989) as well as elsewhere in Southeast Asia. Thus water quality management has been gaining increasing attention. The present study is aimed to determine the water quality parameters in shrimp culture ponds of different villages in Kota mandal, SPSR Nellore district.

A. *Water Quality Requirements*

1) *Salinity:* Salinity plays an important role in the growth of culture organisms through osmoregulations of body minerals from that of the surrounding water. For eg. The optimum range of salinity for black tiger shrimp is between 10 and 25 ppt, although the shrimp will accept salinity between 5 and 38 ppt. since its euryhaline character. The early life stages of both shrimp and prawn require standard seawater salinities but while growing they can with stand to brackish water or even to freshwater.

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However, for better survival and growth optimum range of salinity should be maintained in the aquaculture ponds. Most cultured marine shrimp are euryhaline and adapt easily to salinity fluctuations due to climatological and hydrological factors in a coastal environment.The juveniles are more euryhaline and stronger osmoregulation was performed efficiently at 3-50 ppt for juvenile and 15-50 ppt for the adult (Cheng and Liao 1986). Ferraris et al. (1985) reported that young *P.monodon* showed efficient osmoregulation over salinity ranges of 5-55 ppt. Although *P.monodon* can tolerate a wide range of salinity, the minimal salinity requirement and optimal salinity for its culture are still inconclusive. *P. monodon* postlarvae died at salinities between 5 ppt and 30 ppt up to 22 hours (Law 1988).. Salinities of 15 to 25 ppt are considered ideal for *P. monodon* growout (Boyd 1989).Molting in extremely high or low salinities may require more time and energy in normalizing hemolymph osmolality.

2) *Dissolved Oxygen:* In general, the rate of diffusion of oxygen depends primarily on the oxygen deficit in water, the amount of water surface exposed to the air and the degree of turbulence. Typically, dissolved oxygen is measured either in mg. per litre (mgI-) or parts per million (ppm) with O ppm representing total oxygen depletion and 15 ppm representing the maximum or saturation concentration.The solubility of oxygen in water decreases as the water temperature increases. Oxygen is one environmental parameter that exerts a tremendous effect on growth and production through its direct effect on feed consumption and metabolism and its indirect effect on environmental conditions. Oxygen affects the solubility and availability of many nutrients. Low levels of dissolved oxygen can cause changes in oxidation state of substances from the oxidized to the reduced form. Lack of dissolved oxygen can be directly harmful to culture organisms or cause a substantial increase in the level of toxic metabolites. It is therefore important to continuously maintain dissolved oxygen at optimum levels of above 3.5 ppm. *P.monodon* can with stand DO as low as 0.35 mg/L, with no mortality at 1.2 mg/L (Ting 1971). However, Law (1988) reported that all post larvae perished at DO levels below (0.5 mg/L. About 35% mortality was found when the DO level dropped to 1 mg/L and raised back to 6.3 mg/L. He suggested that the DO level should be kept above 2 mg/L at all times.
3) *P^H:* P^H or the concentrations of hydrogen ions (H+) present in pond water is a measure of acidity or alkalinity. The pH scale extends from 0 to 14 with 0 being the most acidic and 14 the most alkaline. PH 7 is a condition of neutrality and routine aquaculture occurs in the range 7.0 to 9.0 (optimum is 7.5 to 8.5). Exceedingly alkaline water (greater than pH 9) is dangerous as ammonia toxicity increases rapidly. At higher temperatures fish are more sensitive to pH changes. It is an important chemical parameter to consider because it affects the metabolism and other physiological processes of culture organisms. A certain range of pH (pH 6.8 – 8.7) should be maintained for acceptable growth and production. But in semi- intensive culture, re-optimum range is better maintained between pH 7.4 – 8.5. pH 7 is the neutral point and water is acidic below pH 7 and basic above pH 7. An alkalinity above 20 ppm CaCO3 is preferred in prawn or shrimp ponds. (Wedemeyer and Yasutake 1978) and may have similar effects on shrimp. Low pH also increases the fraction of unionized hydrogen sulfide (H2S), the toxic form of sulfide.
4) *Ammonia:* Ammonia is the second gas of importance in fish culture; its significance to good fish production is overwhelming. High ammonia levels can arise from overfeeding, protein rich, excess feed decays to liberate toxic ammonia gas, which in conjunction with the fishes, excreted ammonia may accumulate to dangerously high levels under certain conditions.Ammonia exists in water in both ionized (NH4) and unionized (NH3) forms.The fraction of NH3 depends on pH, temperature, and to a lesser extent on salinity (Bower and Bidwell 1978). As pH or temperature rises, NH3 increases relative to NH4, and the toxicity of ammonia to animals increases. Chen and Sheu (1990) reported that as pH level gets higher than 8.2, increasing pH level in given ammonia solution could increase the ammonia toxicity to P. japonicas post larvae.
5) *Hardness:* Numerous inorganic (mineral) substances are dissolved in water. Among these, the metals calcium and magnesium, along with their counter ion carbonate (CO3 -2) comprise the basis for the measurement of hardness. Optimum hardness for aquaculture is in the range of 40 to 400 ppm of hardness. Hard waters have the capability of buffering the effects of heavy metals such as copper or zinc which are in general toxic to fish. The hardness is a vital factor in maintaining good pond equilibrium.

a) *Water Management:* Maintaining water quality means keeping the concentration of harmful substances in water low enough so that they do not adversely affect behavior and physiology of the cultured organisms.. A study showed that survival rate of *P.monodon* postlarvae is directly influenced by organic content and dissolved oxygen concentration in the culture water (Millamena 1990). The detrimental effects of organic pollution are high BOD, low DO, high NH4, N and NO2, N. At sub–lethal levels, a combination of these pollutants can induce stress and result in decrease survival (Millamena 1990). Therefore, in an intensive culture system the main approaches to reduce risks of poor water quality are: (1) providing efficient feeding strategies to reduce unnecessary organic loading, (2) maintaining the system in a highly oxidized state. The decomposition of organic materials operates much more efficiently and completely in aerobic than in anaerobic environments; (3) conducting proper water exchange to eliminate or dilute organic materials and toxic substances; (4) maintaining a stable phytoplankton community to absorb toxic substances; and (5) maintaining a beneficial bacteria community to convert toxic substances into non-toxic ones

Water quality parameters for shrimp farming

Water Parameter	Optimum level
Salinity	10-25 ppt
Dissolved oxygen	>3.0 ppm
pH	7.5-8.5
Total Ammonia Nitrogen	<1.0 ppm
Total Nitrate Nitrogen	<5.0 ppm
Biological Oxygen Demand (BOD)	< 10 ppm
Chemical Oxgen Demand (COD)	<70 ppm
Sacchi disc visibility	25-45 cm
Carbonates & Bicarbonates	120-150ppm

II. AIMS AND OBJECTIVES

The present study is aimed to study the water quality parameters in shrimp culture ponds located in Kota mandal SPSR Nellore district.

III. MATERIALS AND METHODS

Water samples were collected from four corners of various shrimp culture ponds and important water quality parameters were estimated during third month of culture period.

A. pH

pH was measured using glass electrode pH meter(Digital pH Meter,modal 55)

B. Salinity

Salinity was measured using Portable Refractometer.

C. Dissolved Oxygen

Water sample is collected into a reagent bottle of opproximately 250ml Capacity and 1ml of mangnous sulphate is added, followed by 1ml of alkaline iodide. The bottle is stoppered and shaken well than it is kept aside in darkness for some time for the settlement of the precipitate. The stopper is removed and 1ml of con H2So4 is added slowly to dissolve precipitate. The sample is shaken well and 50ml of it is taken into the conical flask, 1or2 drops of starch solution is added an indicator. This is titrated against 0.025 N hypo till blue color disappears.

D. Total Alkalinity

Take 25 ml of sample. Add 2 drops of Phenolphthalein indicator and titrated against 0.02 H2So4. The endpoint disappearance of pink color. This will give carbonate alkalinity. In the same sample add 2 drops of methyl orange and 2 drops of bromocresol and titrated against 0.02 N H2So4. Endpoint is appearance of orange color. This will give the total alkalinity.

E. Total Hardness

Measure 5ml of the sample in a 150 ml conical flask. Add 2ml of hardness buffer and drops of erichrome black-T indicator and titrate with EDTA solution. At the end point the solution will change from wine red to pure blue. Calculate the total hardness with the equation.

Calcium Hardness: Take 5ml of sample +5 ml of 1N NaoH and a pinch of Muroxide Indicator. This is titrated against Standard EDTA. End point is Red to Violet.

F. Nitrite

50ml of sample add with 1ml of sulphanamide, allow to 2min add 1ml of NNED allow to Stand for 10 min read at 540 nm.

G. Ammonia

50 ml of sample add with 2ml of phenol solution, 2ml of sodium nitroprusside, 5ml of oxidizing solution mix well. Allow to stand for one hour at 20^0c-27^0c cover with Aluminium foil, read at 640nm in a spectrophotometer.

IV. RESULTS & DISCUSSION

The present investigation is aimed to study the water quality parameters in shrimp culture ponds in four different regions of Kota Mandal, Nellore District. Important water quality parameters like pH Salinity, Alkalinity, Hardness, Dissolved oxygen, Ammonia levels were monitored during 3rd month of culture. The water depth is between 0.8 to 1.5m depending upon the stage of culture in different shrimp culture ponds. 100 cm water level was maintained in throughout the culture period. In the present study stocking density is of 20-30/m2 in all shrimp culture ponds.

Shrimp pond water quality is influenced by both environmental and management factors. Water exchange is a management tool for that is intended to reduce organic and solid loadings

In a shrimp pond; If water exchange is not being practiced or is significantly reduced it could be expected that the concentrations of solids, nutrients and organic matter would increases in the pond system. There are other environmental characteristics that might influence water quality, these are the nature and condition of the pond bottom, aeration level, lime applications, feeding rate and stocking density.

pH is important parameter to control growth and survival of shrimps. pH is vital environmental characteristics and it is also effects the metabolisms and other physical process used to reduce soil acidity. The most common cause of high pH is high rate of photosynthesis by dense phytoplankton blooms . The pH in the shrimp production ponds is affected by the phytoplankton bloom activity, water alkalinity, pond soil pH and lime applications. The low pH values in the shrimp culture ponds(Table 2, 3, 4) are probably due to lack of lime application when compared to shrimp culture ponds of Konduru village(table1) . Extremely low pH can stress and cause soft shell and poor survival.

Salinity is important parameter to control growth and survival. The salinity was maintained 15 to 17ppt in Konduru (Table1) area when compared to other areas. Shrimps cultured in Konduru area shows good growth and survival compared to other ponds (tables 2,3,4). In high salinity the shrimps will grow slowly but they are healthy and resistance to diseases. In The low salinity shrimps are prone to diseases.

Collection of ammonia was nil from the ponds of Konduru village(Table1) While little Ammonia was noticed in all three other villages (table-2,3&4) The maintenance of good water and soil quality is essential optimum growth and survival of shrimp. The level of physical, chemical and biological parameters control the quality of pond water. Ammonia is the main end-product of protein catabolism in crustaceans and can account for 40% to 90% of nitrogen excretion (Parry, 1960). As ammonia concentrations in water increase ammonia excretion by aquatic organisms diminishes, and levels of ammonia on blood pH and adverse effects on enzyme-catalyzed reactions and membrane stability. Ammonia increases oxygen consumption by tissues, gills, and reduces the ability of blood to transport oxygen. In water, ammonia can also be derived from microbial metabolism of the nitrogenous compounds under low oxygen condition. Ammonia exists in water in both ionized (NH4) and unionized (NH3) forms. Unionized ammonia is considered the more toxic form of ammonia due to its ability to diffuse readily across cell membrane (From and Gillette 1968; Emerson et al. 1975). The fraction of NH3 depends on pH, temperature, and to a lesser extent on salinity (Bower and Bidwell 1978). As pH or temperature rises, NH3 increases relative to NH4, and the toxicity of ammonia to animals increases. Chen and Sheu (1990) reported that as pH level gets higher than 8.2, increasing pH level in given ammonia solution could increase the ammonia toxicity to P. japonicas post larvae.

Ammonia concentrations in water influence the rate production in aquaculture.

Dissolved Oxygen plays an important role on growth and production through its direct effect on feed consumption and maturation. Oxygen affects the solubility and availability of many nutrients. Low level of dissolved Oxygen can cause damages in oxidation state of substances from the oxidized to the reduced from lack of dissolved oxygen can be directly harmful to shrimps and cause a substantial increase in the level of toxic metabolic performances in shrimp and can reduce growth and moulting and cause mortality (Gilles Le Molluae 2001). The dissolved oxygen in all the culture ponds in the in the present study was ranging between 3.1 to 4.2 ppm.

Alkalinity plays a major role in shrimp culture ponds because its involvement in shrimp molting process.Low Alkalinity leads to broad P^{H} variations which results in reduced growth and even mortality in shrimp.High alkalinity levels may stop the process of shrimp molting due to excess salt loss. It also has indirect effects on the primary productivity in the pond.In the present study all ponds toatal alkalinity was maintained within the optimum range, where it slightly exceeded the optimum range in Thupulupalem village (Table:3)

Hardness(Calcium and Magnesium) are essential nutrients for the shrimp. Calcium functions to minimize the rise in P^{H} when photosynthesis rates are high.Hardness in all culture ponds were ranged from (1400-3700 ppm).(Tables:1,2,3&4)

V. SUMMARY & CONCLUSION

A sufficient supply of good quality water is essential to any aquaculture operation. Water quality affects reproduction, growth, and survival of aquatic organisms. The criteria for good quality water vary with the kind of organisms and are established by safe levels, i.e., physical and chemical properties of water which have insignificant adverse effects on shrimp growth and survival. A Chinese proverb in aquaculture states, “Cultivating water is a must for aquaculture,” and emphasizes the importance of water quality management in aquaculture. The factors controlling the composition of pond water are extremely varied and include physical, chemical and biological processes. To keep water properties within safe levels, one must understand those processes so that the elements inhibiting prawn growth and survival can be detected and their impact minimized. Avnimelech and Lacher (1979) found that 35% of the organic carbon, 89% of the nitrogen, and 68% of the phosphorus from the feed are accumulated in the fish pond bottom. In an intensive culture system of *Penaeus monodon*, 80% of the nitrogen from feed remained in the ponds (Chen and Liu 1988). As organic materials and their derivatives accumulate and exceed safe levels, they become a liability to water quality maintenance. Water quality management has been gaining increasing attention.The optimal water quality for shrimp culture, based on the present studies are : salinity 10-25 ppt, pH 7.5-8.5, dissolved oxygen minimum 4 mg/L, NH3, N maximum 0.1 mg/L, nitrite N maximum 1.0 mg/L, unionized hydrogen sulfide 0.005 mg/L. The aims of water management are to provide high quality water and minimize water quality fluctuations. The latter principle is more important than the former in pond applications. The main approaches to achieve optimal culture environment are to reduce organic load, maintain the system in a highly oxidized state, conduct proper water exchange, and maintain a stable phytoplankton community.The principal method to avoid sudden mass mortality of phytoplankton is to keep the phytoplankton from reaching peak of its reproductive cycle. It is worthwhile to understand phytoplankton ecology and find indicator species for the water quality. Circulation – aeration is a must in semi – intensive and intensive culture systems. They promote production. The aim of water exchange is to change the water so that water quality does not change abruptly. A combination of inorganic fertilization, aeration, water exchange, and waste removal can be most efficient in managing water quality.

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

TABLES

Table 1. Water Quality parameters in Shrimpculture Ponds water samples Collected from Konduru Village, Kota Mandal, Nellore district.

Parameter	Units	Pond1	Pond2	Pond3	Pond4	Pond5
PH	0-14	8.47	8.37	8.63	8.69	8.57
Salinity	PPT	15	16	17	15	15
Carbonates	PPm	8	8	12	8	12
Bicarbonates	PPm	178	174	150	152	148
Total Alkalinity	PPm	186	182	162	160	160
Calcium Hardness	PPm	1300	1160	940	840	1260
Magnesium Hardness	PPm	2400	2020	1600	1460	2020
Total Hardness	PPm	3700	3180	2540	2300	3280
Total Ammonia	PPm	0.02	0.04	0.02	0.03	0.03
Dissolved Oxygen	PPm	4	5	4.5	4	5

Table 2. Water Quality parameters in Shrimpculture Ponds water samples collected from Gollapalem Village, Kota mandal, Nellore District.

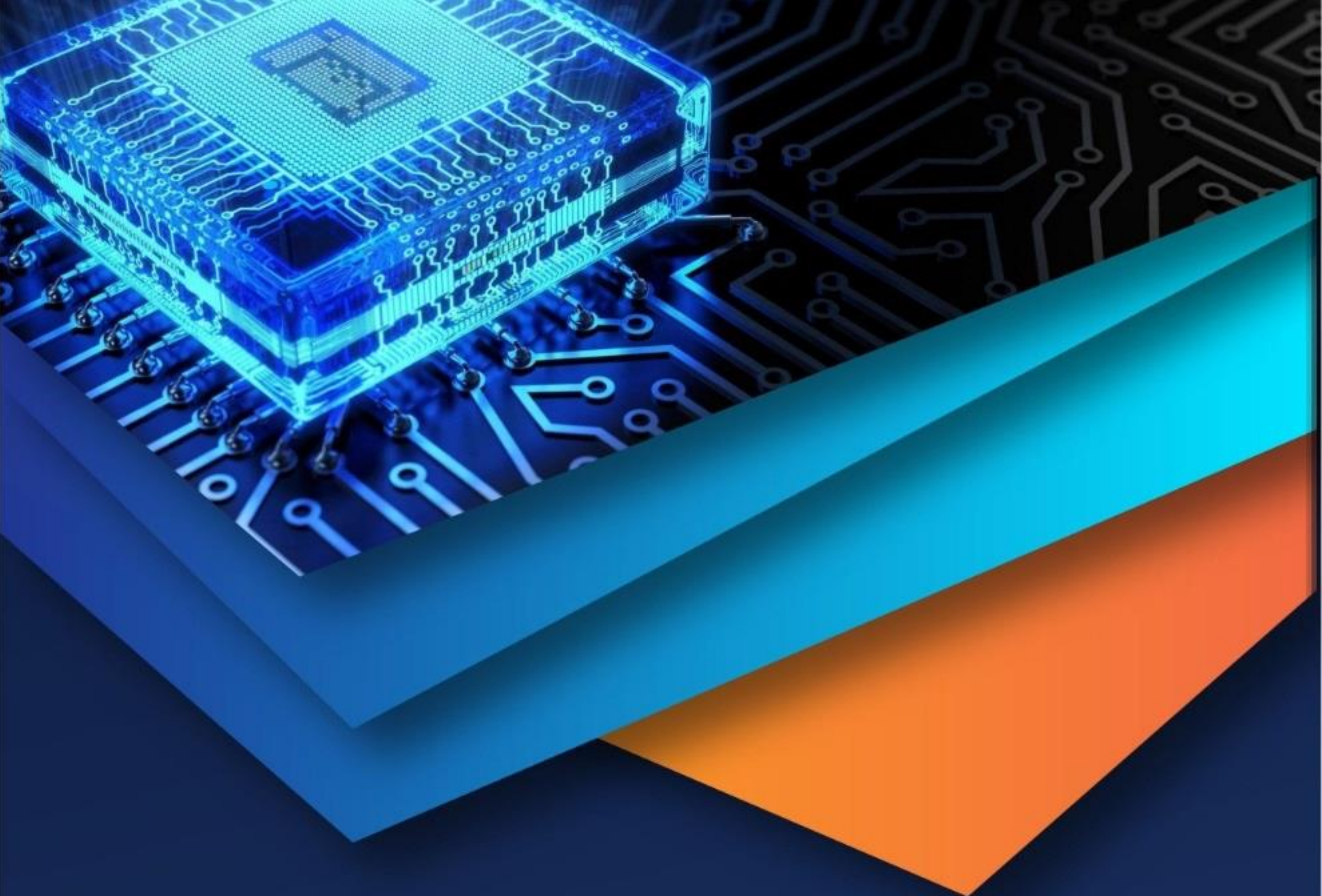
Parameter	Units	Pond6	Pond7	Pond8	Pond9	Pond10
PH	0-14	7.60	7.51	7.61	7.63	7.69
Salinity	PPT	7	6	7	7	7
Carbonates	PPm	0	0	0	0	0
Bicarbonates	PPm	170	166	174	160	170
Total Alkalinity	PPm	180	166	134	140	150
Calcium Hardness	PPm	800	820	900	700	700
Magnesium Hardness	PPm	1200	1320	1460	1400	1100
Total Hardness	PPm	2000	2140	2360	2100	1800
Total Ammonia	PPm	0.34	0.40	0.20	0.30	0.22
Dissolved Oxygen	PPm	2	2.5	2	2	2.5

Table3. Water Quality parameters in ShrimpculturePonds water samples Collected from Thupulupalem Village, Kota Mandal, Nellore District.

Parameter	Units	Pond11	Pond12	Pond13	Pond14	Pond15
PH	0-14	7.50	7.50	7.70	7.70	7.60
Salinity	PPT	7	6	7	7	7
Carbonates	PPm	0	0	0	0	0
Bicarbonates	PPm	256	194	220	224	226
Total Alkalinity	PPm	256	194	220	224	226
Calcium Hardness	PPm	450	700	640	500	740
Magnesium Hardness	PPm	1300	1340	1560	1500	1620
Total Hardness	PPm	1750	2040	2200	2000	2360
Total Ammonia	PPm	0.2	0.24	0.4	0.33	0.26
Dissolved Oxygen	PPm	2.5	2.5	2	2	2

Table 4.Water Quality parameters in Shrimpculture Ponds water samples Collected from Duggarajupatnam Village, Kota Mandal, Nellore District.

Parameter	Units	Pond16	Pond17	Pond18	Pond19	Pond20
PH	0-14	7.9	7.62	7.90	7.9	7.7
Salinity	PPT	7	7	7	4	5
Carbonates	PPm	0	0	0	0	0
Bicarbonates	PPm	200	150	156	156	158
Total Alkalinity	PPm	200	150	156	156	158
Calcium Hardness	PPm	500	500	500	300	300
Magnesium Hardness	PPm	1200	1200	1200	1100	1200
Total Hardness	PPm	1700	1700	1700	1400	1500
Total Ammonia	PPm	0.01	0.20	0.38	0,04	0.06
Dissolved Oxygen	PPm	2.5	3	2.5	2.5	2.5



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