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STUDIES ON SEASONAL VARIATION IN WATER QUALITY OF POLYCULTURE FISHERY PONDS

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ABSTRACT

The present study was carried out from December'2019 to November'2021 for two years to analyse the seasonal variations in selected polyculture ponds in Atapaka, Kaikalur Mandal and Tadinada, Kalidindi Mandal of Eluru District of Andhra Pradesh. In the Atapaka polyculture pond, Catla, Rohu and Mrigal are grown. In the Tadinada, Catla, Rohu and Roopchand species are cultured. Catla is a surface feeder. Rohu and Roop Chand feed from the middle level. Mrigal is a bottom feeder. The findings from the analysis of physicochemical parameters were compared with prescribed standard limits.[9] The physicochemical parameters such as pH, Salinity, Dissolved Oxygen, Total Hardness, Calcium as Ca, Magnesium as Mg, Carbonate, Bicarbonate, Hydrogen Sulphide, Ammonia, Nitrates, Nitrites, Total Dissolved Solids, COD and BOD were analysed using standard methods.[2] The results showed that in Atapaka polyculture pond, the physicochemical parameters pH, carbonates, calcium, nitrates, ammonia, and DO were found within the permissible limits.[9] TDS, Salinity, Total Hardness, and Magnesium have exceeded the specified standards. Tadinada polyculture pond has also shown a similar trend. Seasonal or diel variations have not affected the average fish production in culture ponds because of regular monitoring of water quality and water replenishment. Despite the variations in the physicochemical parameters, the productivity in the ponds is not affected because of resistance supplemented by the antibiotics and probiotics used for the culture fishery.

KEYWORDS: Catla, Rohu, Polyculture Pond, Physico-chemical parameters, Permissible limits.

INTRODUCTION

Fish is a significant protein-rich food source and an extensive cash crop in most of the world's provinces. Demand for fish products has been rising daily due to the increasing population burden and health consciousness. Aquaculture is believed to be eco-friendly because it can use farm resources and water to provide both food and revenue. By the year 2050, it is expected that the world population may reach up to 9.8 billion, which may lead to a further increase in the demand for food resources.

Aquaculture plays a significant role in meeting the increasing demand for protein on a global scale. India is the third largest fish-producing country in the world. Aquaculture provides the livelihood for more than twenty-eight million people in India. The water quality of the culture ponds is essential for the influential fish culture. Water plays a significant role in confirming the success or failure of an aquaculture operation.

A study of seasonal changes in water quality of physicochemical parameters from different aquaculture ponds of Badarpur, Assam, was carried out for one year.[25] Various physicochemical parameters such as temperature, pH, conductivity, alkalinity, dissolved oxygen, free CO_2, total hardness, nitrates and phosphates were analysed and were found to be within permissible limits.

The seasonal variations in physicochemical parameters of two freshwater ponds were studied at Nizerneshwar and Nimon ponds, Ahmednagar, Maharashtra. The dissolved oxygen concentrations were found to be higher in summer compared to winter and monsoon. The parameters, namely free CO_2, total alkalinity, total hardness, temperature, and pH, were higher during summer than in winter and monsoon seasons.[6]

MATERIALS AND METHODS

The study has been carried out for two years, from December'2019 to November'2021. Water samples were collected from polyculture fishery ponds of Atapaka - 16.5605197^0N and 81.2284689^0E (Kaikalur Mandal) and Tadinada - 16.561836^0N and 81.319212^0E (Kalidindi Mandal) villages in Eluru District, Andhra Pradesh. The water quality of two poly culture fishery ponds was assessed in different pre-monsoon and post-monsoon seasons.

Atapaka is one of the villages in Kaikalur mandal. The geographical area of this village is 437 hectares. Catla, Rohu and Mrigal are grown. Aquaculture is the major occupation of the population. Few people adopt backyard poultry farming, cattle farming and growing fodder for their livelihood.

Tadinada village is in Kalidindi mandal. The total area of this village is 1444 hectares. Fishes like Catla, Rohu and Roop chand are grown here. The major occupation of the people in Tadinada is aquaculture. Few people depend on backyard poultry farming, cattle, sheep and goat rearing for their livelihood. This sampling location is surrounded by various culture ponds like shrimp culture ponds, spawn farms and fishery ponds.

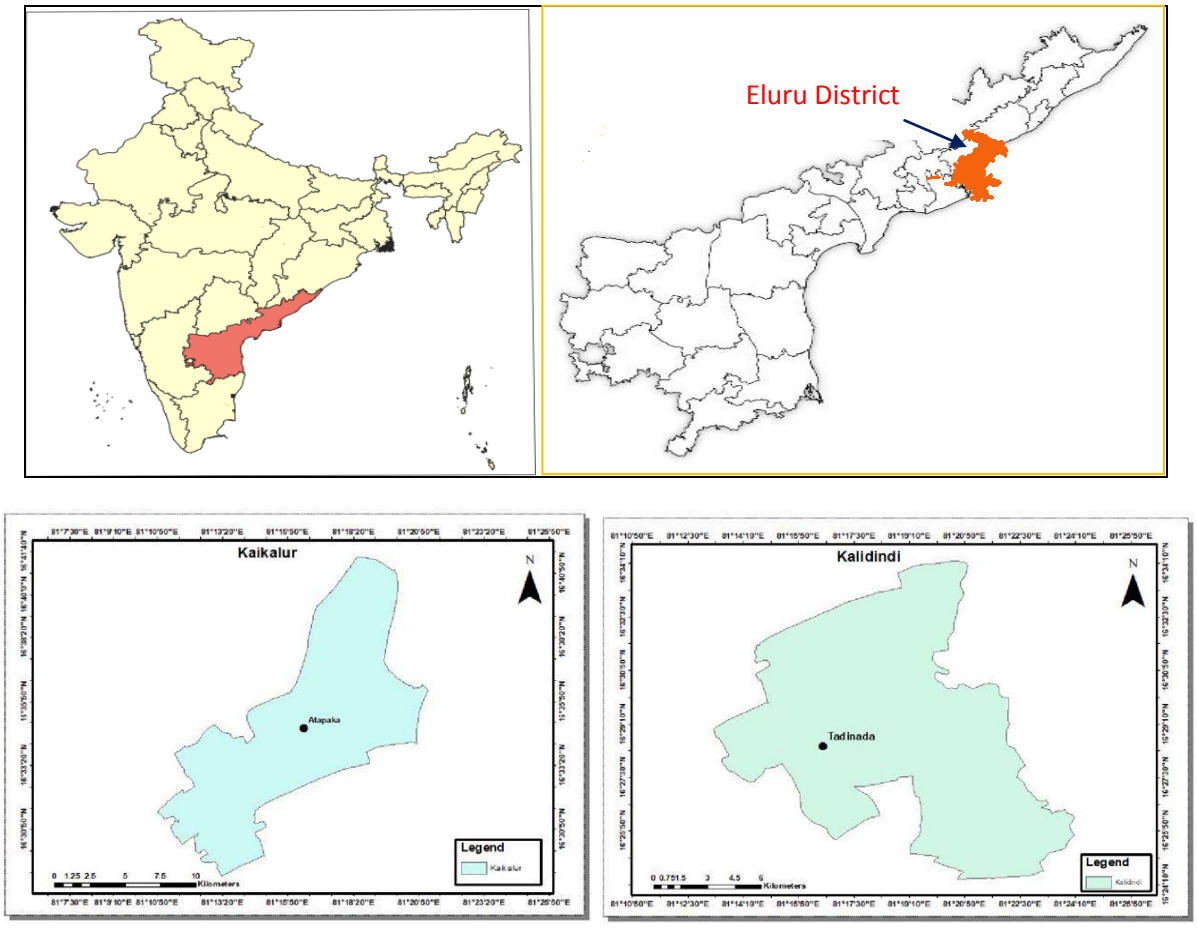

Fig: 1 Study Areas.

In polyculture, more than one species is reared in a single pond. The feed in the pond will be utilized effectively by rearing many species in the same pond. The preparation of a pond plays a significant role in polyculture. Usually, a six to eight feet depth of the pond is required for polyculture.

Pre-stocking, stocking and post-stocking are the various steps to prepare the pond for polyculture. In pre-stocking, firstly stocked seed aquatic weeds, predators and weed fishes were removed. Ploughing was done after drying the ponds till the soil started cracking to eradicate the undesired fauna and the release of obnoxious gases from the bottom of the ground. Liming was done in the pond to adjust the pH of water and soil, disinfection and mineralization of the organic matter in the pond. Stocking of the pond was carried with the proportionate number of surface, column and bottom feeders. Post-stocking includes fertilization, additional feeding, water quality and fish health.

The scientific name of Catla is *Catla catla*, the leading Indian major carp. Catla is a surface and mid-water feeder. Adults feed on zooplankton, but young one's feed

both zooplankton and phytoplankton for feeding. It is usually grown in combination with *Labeo rohita* and *Cirrhinus mrigala*.

Labeo rohita feed from the middle level of water, and the main feed of Rohu fish is plant and putrescent substances. It is a fast-growing species. Rohu grows faster than Mrigal but slower than Catla.

Cirrhinus mrigala is a bottom feeder. Diatoms, filamentous green algae, higher plant fragments, vegetable decays, mud and debris, are food for adult fish.

The scientific name of Roop chand is *Piaractus brachypomus*. It is a middle swimmer. Rapid growth, superior quality, an omnivorous food habit, and even the ability to feed low-cost varieties. It is highly tolerant of the environment and at low dissolved oxygen levels.

Samples were collected from 6.00 to 8.00 am in a wide germ-free translucent plastic jar of five litres and drawn at 10 to 15 cm depth from the surface of the water. Various physicochemical parameters such as pH, Salinity, Dissolved Oxygen, Total Hardness, Calcium as Ca, Magnesium as Mg, Total Alkalinity, Carbonates, Bicarbonates, Hydrogen Sulphide, Ammonia, Nitrites, Nitrates, Total Dissolved Solids, COD and BOD were estimated in the laboratory using standard methods.[2] For the analysis of DO, water samples were collected in 300 ml BOD bottles. $MnSO_4$ and the alkali iodide azide were mixed into the samples instantly at the collection point to secure the samples for studying DO. Results were expressed in mg/L except for salinity which was represented as ppt.

RESULT AND DISCUSSION

The present study has been done for two years, from December 2019 to November 2021, at Atapaka, Kaikalur Mandal and Tadinada, Kalidindi Mandal of Eluru District. Samples were collected from polyculture fishery ponds during pre-monsoon and post-monsoon seasons. pH, Salinity, Carbonates, Bicarbonates, Total Alkalinity, Total Hardness, Calcium, Magnesium, Nitrates, Nitrites, Ammonia, Hydrogen sulphide, Total Dissolved Solids, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand were estimated.

In Atapaka, the pond water has a pH of 8.4 and a salinity of 2 ppt during the pre-monsoon season. The collected water sample showed 20 mg/l of carbonates and 400 mg/l of bicarbonates. The pond waters have exhibited 420 mg/l of alkalinity throughout the study. A total hardness of 600 mg/l was found. The pond water sample showed a calcium concentration of 120 mg/l and magnesium of 135 mg/l. Nitrates in the present water sample were 25.82 mg/l and nitrites were nil. Ammonia detected during the study was 0.22 mg/l. The total dissolved solids recorded in the pond water during the study period was 1600 mg/l. In the present investigation, the DO in the sample was 7.4 mg/l. The pond water showed a BOD content of 4.56 mg/l and 480 mg/l of COD during the pre-monsoon season.

During post-monsoon season, Atapaka pond water has a pH of 8.25 and a salinity of 4 ppt. The carbonates and bicarbonates concentrations recorded in the pond were 10 mg/l and 250 mg/l, respectively. The collected water sample has total alkalinity of 260 mg/l and a total hardness of 1300 mg/l. Calcium of 180 mg/l and magnesium of 245 mg/l were recorded. In the present study, nitrate and nitrite levels identified in the pond during the post-monsoon season were 8.07 mg/l and 0.3 mg/l, respectively. The sample has ammonia of 0.11 mg/l. The Hydrogen sulphide (H_2S) was 0.2 mg/l. The pond water has total dissolved solids of 3600 mg/l. During the post-monsoon season, 5.4 mg/l of dissolved oxygen was noted. BOD was 21.6 mg/l, and the COD was indicated as 160 mg/l.

In the present study, the average pH of the samples during the study period was alkaline, i.e., 8.25 to 8.4. The pH was higher in pre-monsoon (8.4) than post-monsoon (8.25). However, both concentrations are favourable for fish culture. The salinity during the study ranged from 2 to 4 ppt. The higher salinity of 4 ppt was found in post-monsoon, and the lower was recorded in the pre-monsoon season. The salinity recorded during the post-monsoon season (4 ppt) exceeded the desirable limit of 2 ppt.

During the study period, carbonates ranged between 10 and 20 mg/l. The concentration was higher during pre-monsoon (20 mg/l) and less in post-monsoon. The bicarbonate concentrations varied between 250 mg/l in post-monsoon and 400 mg/l in pre-monsoon during the study period. The total alkalinity in the water varied widely between 260 and 420 mg/l. The total alkalinity was higher in the pre-monsoon (420 mg/l) than in the post-monsoon season (260 mg/l).

In the present study, the total hardness in Atapaka pond water ranged from 600 to 1300 mg/l. Total Hardness levels noted in both the seasons were exceeded the prescribed limit of 200 mg/l.[9] In pre-monsoon concentration of total hardness noted as 600 mg/l was within the acceptable limit of 600 mg/l standard acceptable in the absence of alternate source.[9] The calcium results in the present study varied between 120 and 180 mg/l. post-monsoon season exhibited higher concentrations of calcium 180 mg/l compared to the pre-monsoon (120 mg/l). The magnesium levels in the pond waters were between 135 to 245 mg/l. Higher magnesium levels were noticed during the post-monsoon season (245 mg/l) compared to the pre-monsoon season value of 135 mg/l. Nitrates in the pond water varied between 8.07 and 25.82 mg/l. The nitrate values were within the acceptable limit of 45mg/l.[9] The lower levels found in the present study were ideal fish cultures. During the pre-monsoon season, high amounts of nitrates (25.82 mg/l) were observed and low levels were recorded

post-monsoon (8.07 mg/l). The concentration of nitrites was from 0 to 0.3 mg/l, which was higher during post-monsoon at 0.3 mg/l and was nil in pre-monsoon. During the study, ammonia concentration varied between the seasons, ranging from 0.11 to 0.22 mg/l. The concentration of ammonia that appeared during pre-monsoon was 0.22 mg/l was higher than post-monsoon (0.11 mg/l).

The Hydrogen sulphide (H_2S) appeared between 0.2 and 0.31 mg/l. The H_2S levels were above the acceptable 0.05 mg/l.[9] Both pre-monsoon and post-monsoon seasons exhibited higher values. The total dissolved solids in the Atapaka pond water varied extensively from 1600 to 3600 mg/l. The observed TDS value in both seasons was higher than the acceptable limit of 500 mg/l.[9]

The dissolved oxygen levels ranged 5.4 to 7.4 mg/l, the range conforms to the limit of within the limit of 5 mg/l for commercial fishing.[31] The higher DO level was noted during the pre-monsoon season (7.4 mg/l) compared to post-monsoon. The BOD content during both seasons was between 4.56 and 21.6 mg/l. post-monsoon showed a higher concentration of BOD at 21.6 mg/l than pre-monsoon (4.56 mg/l). BOD observed during both the seasons were above the prescribed limit for commercial fishing of 3 mg/l.[30] The COD content in the present pond water varied from 160 to 480 mg/l. The higher COD registered as 480 mg/l in the pre-monsoon and lower COD level during post-monsoon as 160 mg/l were much higher than the limit of 50 mg/l.[26] But specifically, there is no mention of the COD limit for culture ponds[9] and[30] for commercial fishing.

Table 1: Comparison of mean values of water quality parameters in Atapaka Poly culture fishery pond.

S. No	Parameters	Atapaka Poly culture fishery pond	
		Pre-Monsoon	Post- Monsoon
1	pH	8.4	8.25
2	Salinity PPT	2	4
3	CO_3 mg/l	20	10
4	HCO_3 mg/l	400	250
5	Total alkalinity mg/l	420	260
6	Total Hardness mg/l	600	1300
7	Ca^{2+} mg/l	120	180
8	Mg^{2+} mg/l	135	245
9	NO_3 mg/l	25.82	8.07
10	NO_2 mg/l	0	0.3
11	Ammonia mg/l	0.22	0.11
12	H_2S mg/l	0.31	0.2
13	TDS mg/l	1600	3600
14	DO mg/l	7.4	5.4
15	BOD - 5-day mg/l	4.56	21.6
16	COD mg/l	480	160

During the pre-monsoon season, the polyculture pond in Tadinada has shown a pH of 8.3 and 4 ppt of salinity. The collected water sample exhibited carbonates of 20 mg/l and bicarbonates of 540 mg/l. During the study, 560 mg/l of alkalinity was measured. In the pond water sample, the total hardness was 1000 mg/l. Calcium and magnesium levels in the water sample were 80 mg/l and 211 mg/l, respectively. The present water sample had 27.36 mg/l of nitrates. During the pre-monsoon season, nitrites were zero. Whereas ammonia of 0.2 mg/l was observed during the study. Hydrogen Sulphide was 0.28 mg/l. In the pre-monsoon season, 3100 mg/l of total dissolved solids were noted. The water showed 7.4 mg/l of DO and 8.25 mg/l of BOD. During the pre-monsoon season, the pond water exhibited 560 mg/l of COD.

During post-monsoon, the selected polyculture pond in Tadinada reported an alkaline pH of 8.05. A salinity of 2 ppt was noted in the pond water during post-monsoon season. The collected water sample showed 16 mg/l of carbonates and 400 mg/l of bicarbonates. The total alkalinity of 416 mg/l was noticed. The pond water had a total hardness of 550 mg/l. 70 mg/l of calcium and 100 mg/l of magnesium were found in the pond water. Nitrates in the current water sample were 6.81 mg/l. Nitrites are not recorded during post-monsoon season. In the present study, 0.2 mg/l of total ammonia was noted. Hydrogen Sulphide of 0.3 mg/l was noted in the sample. The total dissolved solids in the pond water were 2500 mg/l. The analysed water sample has 5.5 mg/l of DO and 4.95 mg/l of BOD. In the post-monsoon season, the pond water showed 128 mg/l of COD.

In the present study at Tadinada, during the pre-monsoon and post-monsoon seasons pH of the pond water varied from 8.05 to 8.3. The pH during both seasons was alkaline and conforming to the standard range of 6.5 to 8.5.[9] Pre-monsoon showed a higher pH of 8.3 than post-monsoon. The salinity concentrations during the investigation ranged from 2 to 4 ppt. The limit for salinity was 2 ppt[14] exhibited in post-monsoon.

The range of carbonates obtained was between 16 and 20 mg/l during the study period of two years. The levels of carbonates noticed were higher in pre-monsoon (20 mg/l) and dropped to 16 mg/l post-monsoon. The bicarbonates ranged from 400 to 540 mg/l. The concentrations of bicarbonates were higher in pre-monsoon compared to post-monsoon levels is 400 mg/l. The total alkalinity of the pond water showed a significant variation from 416 to 560 mg/l. Both the seasons had excess alkalinity and was above the acceptable limit of 200 mg/l but below the specified limit of 600 mg/l[9] in the absence of alternative source.

In the present study, the total hardness in the Tadinada culture pond varied from 550 to 1000 mg/l. In post-monsoon season higher levels of total hardness (1000 mg/l) were observed compared to pre-monsoon. In both seasons, total hardness levels were observed beyond the specified limit of 200 mg/l.[9] The pond water showed calcium ranging from 70 to 80 mg/l. A little higher value of calcium (80 mg/l) was noted in the pre-monsoon season, which was higher than the acceptable limit of 75 mg/l.[9] Magnesium varying from 100 to 211 mg/l was noticed in a current water sample. Magnesium was found to be higher during pre-monsoon at 211 mg/l, which was above the prescribed limit of 30 mg/l.[9]

In the present investigation, the nitrate levels in the pond water were between 6.81 mg/l and 27.36 mg/l. The observed results of nitrates were within the acceptable limit of 45 mg/l.[9] Pre-monsoon season exhibited a higher concentration of nitrates at 27.36 mg/l than post-monsoon at 6.81 mg/l. No nitrites were found during both seasons in the pond water. In the culture pond, similar ammonia concentrations of 0.2 mg/l were noticed in both pre-monsoon and post-monsoon seasons.

Hydrogen sulphide concentration was recorded from 0.28 to 0.3 mg/l in the collected water samples during the entire study period of two years. Slight variations were observed in the levels of hydrogen sulphide found during pre-monsoon and post-monsoon seasons. Post-monsoon showed a moderately higher value of 0.3 mg/l than pre-monsoon at 0.28 mg/l. However, during both seasons, H_2S were higher than the prescribed limit of 0.05 mg/l.[9] The Tadinada pond has a wide range of total dissolved solids varying from 2500 to 3100 mg/l, which were higher than the standard limit of 500 mg/l.[9] The concentration of TDS during both seasons was far exceeding the limit[9] prescribed for TDS, i.e., 500 mg/l.

During the entire study period, the pond water showed a dissolved oxygen level ranging from 5.5 to 6.2 mg/l, which was found to conform with the value of 5 mg/l specified for commercial fishing.[31] Pre-monsoon season had a higher concentration of DO (6.2 mg/l) than in post-monsoon at 5.5 mg/l. The study pond's average BOD content varied from 4.95 to 8.25 mg/l during pre-monsoon and post-monsoon. The higher was found in the pre-monsoon season (8.25 mg/l) than in the post-monsoon (4.95 mg/l). However, during pre- and post-monsoon seasons, the values were higher than the prescribed limit of 3 mg/l for commercial fishing.[30] The water in the present study pond has a COD ranging from 128 to 560 mg/l. During pre-monsoon high COD of 560 mg/l was noted compared to post-monsoon. In both the seasons, COD was found to be above the limit of 50 mg/l.[26] At present there is no specific limit for COD[9] and in[30] for commercial fishing. However, the presence of COD indicates inorganic pollution levels in the water body.

Table 2: Comparison of mean values of water quality parameters in Tadinada Polyculture fishery pond.

S. No	Parameters	Tadinada Polyculture fishery pond	
		Pre-Monsoon	Post-Monsoon
1	pH	8.3	8.05
2	Salinity ppt	4	2
3	CO_3 mg/l	20	16
4	HCO_3 mg/l	540	400
5	Total alkalinity mg/l	560	416
6	Total Hardness mg/l	1000	550
7	Ca^{2+} mg/l	80	70
8	Mg^{2+} mg/l	211	100
9	NO_3 mg/l	27.36	6.81
10	NO_2 mg/l	0	0
11	Ammonia mg/l	0.2	0.2
12	H_2S mg/l	0.28	0.3
13	TDS mg/l	3100	2500
14	DO mg/l	6.2	5.5
15	BOD - 5-day mg/l	8.25	4.95
16	COD mg/l	560	128

Polyculture is a system in which two or more fish species with diverse habitats and food preferences are cultured in a single pond. The stocking density is done so that there should be no competition for food or space. Yield from

polyculture is higher than monoculture production under similar conditions for freshwater fish farming. Catla, Rohu, Mrigal, Roop chand, silver carp, grass carp etc., are some common fish species in Indian polyculture.

Effective management of water quality is essential to obtain optimum fish production. The ideal growth of fish culture mainly depends on optimal environmental conditions and water utilisation. The role of various parameters such as pH, Salinity, Dissolved oxygen, Hardness, Nitrates, Nitrites, Ammonia, Carbonates, Bicarbonates, Total Alkalinity, Chemical and Biochemical Oxygen Demand (COD and BOD) etc., are important for sustaining a healthy aquatic environment for the production in ponds.[3]

The water quality was monitored regularly for two years, and compared the values between 2019 – 21, and also to analyse the variations in selected polyculture ponds in Atapaka, Kaikalur Mandal and Tadinada, Kalidindi Mandal of Eluru District, Andhra Pradesh.

pH denotes a solution's acidic or basic nature at a given temperature. It signifies the general ecological condition.[2] The acceptable range for fish growth is 6.5 to 9.0, and the pH of 4.0 to 6.5 and 9.0 to 11.0 exerts stress to fish.[13] pH less than 6.5 affects fish growth, and spawn mortality occurs below 5.0. Death of fish is almost inevitable at pH less than 4.0 and above 11.0. In the present investigation, pH values were recorded between 8.05 to 8.4, indicating a moderately alkaline condition that is non-toxic to culture fish. pH in both stations conformed with the prescribed limit.[9] These findings were similar to.[5,18,4] The concentrations of carbonates and bicarbonates also influence the pH level in the water body. The application of lime in the culture pond helps to maintain the near-neutral pH level.[23] The pH of 6.35 to 8.03 was observed to be ideal for collapsible, concrete, earthen and natural ponds that were suitable for fish culture at Llorin, Nigeria.[22] A slightly acidic to moderately alkaline pH ranging from 6.84 to 8.02 at Kanjia lake, Bhubaneswar is favourable for fish culture.[15] The pH values were observed as 7.8 in the pond, which is slightly alkaline and 7.2 in the tap water sample located near Nandini Mines in Durg District, Chhattisgarh.[32]

Salinity is the total quantity of all ions present in the water. Salinity is a main driving feature affecting the density and growth of aquatic fauna.[17] Usually, in surface waters, the concentration of salinity is based on the drainage, nature of its rock, precipitation, anthropogenic activity in the area and its distance to marine water.[19] Saltwater and freshwater fish usually show varied tolerance to significant changes in salinity.[20] In the present study, salinity was higher during post-monsoon in Atapaka and pre-monsoon in Tadinada was not favourable to the culture. In contrast, the pre-monsoon at Atapaka and post-monsoon at Tadinada were favourable for culture fishery (2 ppt) and was congenial for fish growth. During the time of higher salinity, more than 2 ppt addition of fresh water was done. Salinity of 0.23 to 0.27 ppt recorded and was within the permissible limit for fish culture in Kanjia lake, Bhubaneswar.[15]

The marginal differences appearing in the carbonate values in the present study are not considerable. The deterioration of flora, fauna and organic waste will increase carbonate and bicarbonate levels [11,1,16,29] The total alkalinity of 80 to 200 ppm is ideal for fish growth.[8] In the present study, bicarbonates of 250 to 540 mg/l and alkalinity of 260 to 560 mg/l were reported at both stations during both seasons. The concentrations of HCO_3 and total alkalinity in both the ponds during pre-monsoon and post-monsoon were higher than the permissible limit. The water can be used in locations with no alternative (600 mg/l).[9] Total alkalinity ranging from 27.5 to 55 mg/l was recorded in five aquaculture ponds at Atomic Energy Research Establishment (AERE) premises, Savar, Dhaka, Bangladesh and favoured the growth of fish.[27] In Hau River, An Giang and Can Tho Provinces, nearby aquaculture ponds in Mekong Delta, Vietnam, a wide range of total alkalinity from 60.7 to 67.5 mg/l has supported the growth of fish.[13]

Fish require calcium and magnesium for their metabolic activities, like bone and scale formation. The total hardness from 75 to 150 ppm is ideal for fish culture and above 300 ppm led to fish mortality because of increasing pH, subsequently causing non-availability of nutrients.[8] In both the study areas of Atapaka and Tadinada ponds, total hardness was in the range of 550 to 1300 mg/l. In all the instances, at both stations, total hardness was above 550 mg/l, which is higher than the desirable limit of 200 mg/l.[9] A higher concentration of hardness at 342 mg/l was noted in the monsoon season.[29] The dissolved minerals represent total hardness.[24]

Calcium is a significant nutrient for aquatic fauna and is generally present in all water bodies. Naturally, calcium is present in water, but the addition of sewage waste may be the reason for the increase in the quantity of calcium. Fish gets calcium either through water or from food. The range for free calcium is reported as 25 to 100 mg/l.[33] The present study found calcium concentration between 70 and 180 mg/l. From the findings, it was observed that only at the Tadinada pond during post-monsoon calcium (70 mg/l) was within the acceptable range of 75 mg/l.[9] In the remaining study areas in the Tadinada pond during pre-monsoon and Atapaka culture pond during both seasons, calcium was found above the acceptable limit of 75 mg/l. Still, it was below the alternative permissible limit of 200 mg/l.[9] Calcium of 62 to 86 mg/l was reported during their study on seasonal variation in Lahru pond waters of Himachal Pradesh.[29] Calcium was reported as 390 mg/l in pond water located at Nandani mines in Durg District, Chhattisgarh, India, which was

above the permissible limit of 200 mg/l.[32] Various salt and minerals contain magnesium, and commonly magnesium occurs in association with iron compounds. In both the stations of Atapaka (pre-monsoon and post-monsoon) and Tadinada (pre-monsoon) polyculture ponds, magnesium was found to be above the allowable limit of 100 mg/l.[9] The varying magnesium concentrations were noted from 28 to 36 mg/l in Lahru pond, Himachal Pradesh, within the permissible limit suitable for fish culture.[29] Magnesium reported from 5.37 to 47.58 mg/l in pre-monsoon and 2.87 to 39.04 in post-monsoon in 25 sampling locations at the Cauvery River basin, Karnataka is favourable for fish growth.[31]

The solids present in water in the dissolved form are known as total dissolved solids. The presence of various types of minerals in water denote total dissolved solids. These are mainly composed of carbonates, bicarbonates of calcium, magnesium, sodium, potassium, iron and manganese etc. In the present investigation, the concentrations of total dissolved solids recorded as 1600 mg/l in the Atapaka polyculture pond in pre-monsoon season were within the permissible limit of 2000 mg/l acceptable in the absence of an alternate source.[9] In the remaining study areas of Atapaka pond in post-monsoon as 3600 mg/l and Tadinada pond during both the seasons total dissolved solids recorded from 2500 to 3100 mg/l were found to be abnormally higher than the acceptable limit of 500 mg/l.[9] Total Dissolved Solids were reported from 55.4 to 124.8 mg/l of total dissolved solids in five sample ponds in AERE premises, Savar, Dhaka was within the acceptable limit for the culture of fisheries.[27] Total dissolved solids ranging from 440.86 to 453.59 mg/l were noticed during the study on water quality assessment in four sampling sites of Tanganyika Lake, Africa, following in the acceptable range (<500 mg/l) suitable for fish culture.[18]

Dissolved oxygen affects all aquatic specie's physiology, distribution, behaviour and growth.[28] Atmospheric air and photosynthetic planktons are significant sources of oxygen. During the day, photosynthesis is the primary cause of the release of dissolved oxygen. The process of respiration uses dissolved oxygen during the night. Usually, dissolved oxygen contents are lowest just before sunrise and highest during the late afternoon. The depletion of oxygen in pond water causes poor feeding of fish, starvation, decreased growth rate and high mortality rate either directly or indirectly.[7] Exposure of fish to less than 0.3 mg/l of dissolved oxygen for an extended period causes mortality. A minimum amount of 1 mg/l of dissolved oxygen is crucial for fish to sustain long periods, and 5.0 mg/l is adequate for fish ponds.[12] The present study showed 5.4 to 7.4 mg/l of DO levels, which are higher during pre-monsoon than post-monsoon in both the study ponds at Atapaka and Tadinada. The results of DO were above the desirable limit of 5 mg/l suitable for commercial fishing.[30] Dissolved oxygen concentrations recorded from 6.8 to 7.8 mg/l in all their hatchery studies at Shambhuganj, Mymensingh, Bangladesh was good to support commercial fish production.[21] Dissolved oxygen ranging from 3.7 to 5.7 mg/l was noted in 19 sampling sites from An Giang and Can Tho Provinces at Hau River, Mekong Delta, Vietnam was slightly below the allowable ranges for aquaculture, but not toxic to culture fish.[13]

CONCLUSION

The present study was conducted in polyculture fishery ponds in Atapaka, Kaikalur Mandal and Tadinada, Kalidindi Mandal of Eluru District, Andhra Pradesh, from December'2019 to November'2021. The population in Atapaka and Tadinada villages mainly depend on aquaculture for their livelihood. The study's main aim is to assess seasonal variations in the water quality of two polyculture fishery ponds. A total of 16 physicochemical parameters like pH, Salinity, Carbonates, Bicarbonates, Total Alkalinity, Total Hardness, Calcium, Magnesium, Nitrates, Nitrites, Ammonia, Hydrogen Sulphide, Total Dissolved Solids, Dissolved Oxygen, Bio Chemical Oxygen Demand and Chemical Oxygen Demand were analyzed using standard methods.[2]

The water quality variation in both the polyculture fishery pond was compared. Among the physicochemical parameters, pH, carbonates, calcium, nitrates, ammonia, and DO were within the acceptable limits[9] in both the ponds. Bicarbonates and total alkalinity at Atapaka and in pre-monsoon and post-monsoon Tadinada villages showed wide variations. Total dissolved solids in the pre-monsoon season at Atapaka were within the permissible limit of 2000 mg/l. In the post-monsoon season at Atapaka and during both seasons at Tadinada, TDS exceeded the standard allowable limits. Salinity, Total Hardness, and Magnesium also exceeded the prescribed standards. However, the exigence of the values and the seasonal variations did not exert any abnormal effect on the growth performance of the fish since their culture practice has a close monitoring schedule of quality and water replenishment. The visible variations in the quantity/concentration of variables do not show any adverse impact on cultured fish.

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