Spatio-Temporal Limnological Analyses Resulting to Sustainable Development

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Abstract: Sustainable development in agriculture is the need of the hour. Extensive use of agrochemicals in the agricultural sector for practices like weed control, pest control, enhancing soil fertility, etc. results in a broad range of uninvited effects not only to the agricultural ecosystem but also to the human health owing to the nondegradable nature of these chemicals. This situation is alarming and of serious concern. It's high time to curb our dependency on agrochemicals and instead search for other alternatives, most importantly keeping an eye on their environmental impact. In this prospect, eco-friendly strategies should be adopted to ensure safe and healthy agricultural products for the society. Aquaculture being one of the fastest growing food fabrication sectors, thus we majorly focused on community-based aquaculture on the regions of eastern belt of India. The present study is a diagnostic approach that demonstrates how sustainability challenges can be overcome by utilization of local resources.

Key words: Sustainable development, agriculture, aquaculture, eco-friendly

I. INTRODUCTION

Water is considered to be a vital natural resource and a critical agricultural input (Huang et al., 2015). Water usage is essential for sustainable agricultural escalation and boost of food availability (Grafton et al., 2015). However, strategies for increasing agricultural productivity need to be focussed.

Culture of fish, particularly composite fish culture can be an imperative tool for sustainably recuperating agricultural productivity and for strengthening rural economies (Nagabhatla et al. 2012; Dey and Prein 2006; Dey et al., 2005). Declining water quality is currently a global issue (Mahananda et al., 2010).The water purity varies from place to place in nature (Patil 2013). Mostly, aquatic biota influences the physico-chemical characteristics of an aquatic ecosystem (Sharma et al., 2009). Limnology is defined as the study of fresh water and their inhabitants. The growth and survival of aquatic inhabitants depend on the quality of water (Boyd 1989, 1990, Philips 1991, Jhingran 1985). The quality of water depends on the physical, chemical and biological characteristics of water are known (Zweig et al., 1999; Adeniji and Ovie 1982; Das and Padhi 2014, Padhi et al., 2015).

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Hence the present study is focused on the determination of quality of water in order to utilize the ponds for aquaculture. Fish plays an important role in agriculture sector of India. It provides livelihood to more than 60 million people and earns more than 6800 crore rupees through export. Limnological studies have been carried out by Olopade 2013 and Nikolosky 1963. The Main objectives of the study was to determine physical, Chemical and biological characteristics of ponds in order to utilize them for fish culture and thus generate employment opportunity for gainful earning among rural people by creating awareness among them through training on aquaculture practices. Composite fish farming is the technique to culture different types of compatible and non competitive fishes in the same ecosystem so as to allow them to grow by feeding by making optimum use of different zones (surface, bottom and column) of the ponds without impeding the growth, development and maturity of one another. This is a very profitable method of aquaculture and hence importance has been laid to train the populace for gainful employment.

II. MATERIALS AND METHODS

Study site

Three ponds namely P1, P2 and P3 in three villages in the eastern coastal state of India were chosen for investigation, and such ponds were not utilized for fish cultivation earlier.

Measuring physico-chemical parameters

The parameters chosen were water temperature, pH, dissolved oxygen, total alkalinity, nitrate nitrogen and plankton of water sample. Temperature was recorded using thermometer (accurate up to 0.01 degree Celsius), pH by pH meter, and alkalinity by using phenolphthalein and methyl orange indicators. Dissolved oxygen was measured by Wrinkler's method and nitrate nitrogen were measured by following standard procedures (APHA-1989) using water testing kits (NICE), during the period from November 2018 to October 2019.

Preparation of Ponds for Composite Fish Culture

The ponds were manually cleaned by making free from undesirable plants and weeds manually. Liming of the ponds was done in order to modulate the acidity of soil and water to speed up the decomposition of organic matter; which acts as disinfectant and also as an essential nutrient. Fertilization of the ponds was done after 3 days of liming by manuring with organic manures like cow dung and oil cake (600 kg/ha) which carry almost all nutrients required for fish growth.

Fish feeding and introducing fingerlings in the pond

The inorganic manures were used depending on the soil and water condition of the different ponds as they provide the nutrients, vitamins and minerals to the fish thus increasing natural productivity of the ponds. Artificial feeding was done by providing rice bran, oil cake and kitchen waste as these are cheaply available. After cleaning, liming and fertilizing the ponds during March-April 2018, the fingerlings of 50-100 gm size (approx) purchased from govt. hatcheries were stocked in the ponds for 15 days after fertilization of ponds. Fingerlings of *Catla*, *Rohu* amd *Mrigal* in the ratio of 4:3:3 were selected to get good yield in mixed farming during July 2019.

III. RESULTS AND DISCUSSION

The maintenance of good water quality is essential for both survival and optimum growth (Gupta and Gupta 2006). The water quality standards vary significantly due to different environmental conditions, ecosystem and intended human users EPA 2006. The quality of aquaculture products and their suitability for human consumption may also be affected by water quality (Zweig et al. 1999). Keeping these factors in view, the ponds under study were maintained for aquaculture imparting training to local people also in order to empower them for gainful employment. The water temperature in pond 1 varied from 18.4 to 34.2, in pond 2 from 18.3 to 34.2 and in pond 3 from 18.2 to 34.3 (Table 1 and Figure 1). pH in pond 1 varied from 7.2 to 7.9, in pond 2 from 7.4 to 7.9 and in pond 3 from 7.3 to 7.9 (Table 2 and Figure 2). Total alkalinity showed 80.45 to 174.2 in pond 1, from 91.05 to 196.15 in pond 3 and varied from 89.1 to 184.12 (Table 3 and Figure 3). Dissolved oxygen values varied from 6.0 to 7.6 in pond 1, from 5.9 to 7.8 in pond 2 and from 6.0 to 7.5 in pond 3 (Table 4 and Figure 4). Nitrate nitrogen varied from 1.18 to 4.1 in pond 1, from 2.7 to 4.9 in pond 2 and from 2.7 to 5.1 in pond 3 (Table 5 and Figure 5). Taking all these factors into consideration, the three ponds under study were prepared for fish culture by cleaning, liming, fertilizing, stocking and artificial feeding for harvesting after one year. After having studied, the pond health, treatment was done preparing the ponds for aquaculture following standard prescribed guidelines for pre stocking, stocking and harvesting.

Table 1. Temperature variations observed across the three ponds (P1, P2 and P3) during May, 2019 to January, 2020.

Month-Year	P1	P2	P3
May-19	34.2	34.2	34.3
Jun-19	33.1	33.3	33.4
Jul-19	32.4	32.3	32.6
Aug-19	30.4	30.3	30.4
Sep-19	26.7	26.8	26.7
Oct-19	26.6	26.1	26.1
Nov-19	22.06	22.04	22.01
Dec-19	19.4	19.5	19.4
Jan-20	19.6	19.8	19.9

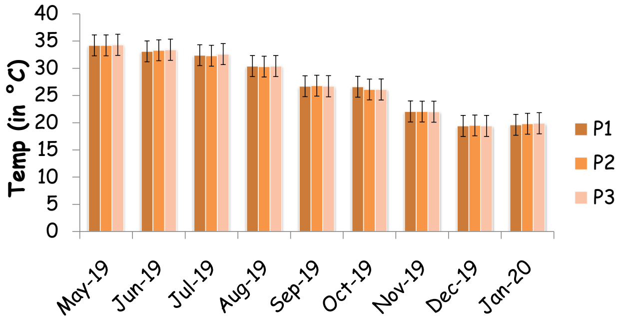

Fig 1. Temp. (0C) in three ponds (Average value) (May, 2019-Jan, 2020)

Table 2. pH variations observed across the three ponds (P1, P2 and P3) during May, 2019 to January, 2020.

Month-Year	P1	P2	P3
19-May	7.9	7.8	7.8
19-Jun	7.8	7.7	7.9
19-Jul	7.8	7.8	7.9
19-Aug	7.9	7.8	7.8
19-Sep	7.9	7.9	7.7
19-Oct	7.8	7.8	7.6
19-Nov	7.7	7.8	7.4
19-Dec	7.4	7.6	7.7
20-Jan	7.6	7.4	7.5

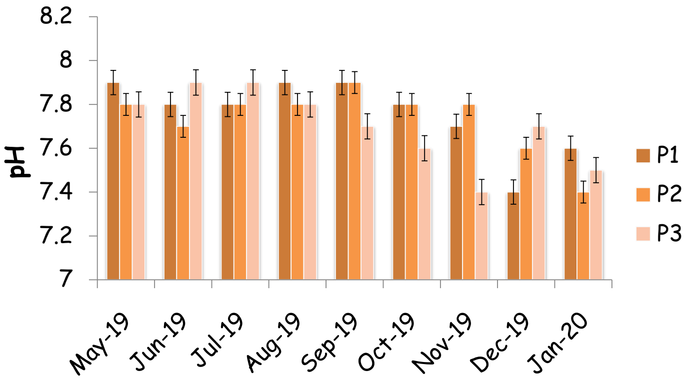

Fig 2. pH in three ponds (Average value) (May, 2019-Jan, 2020)

Table 3. Variations in total alkalinity (mg CaCO3.l-1) observed across the three ponds (P1, P2 and P3) during May, 2019 to January, 2020.

Month-Year	P1	P2	P3
May-19	174.2	196.15	184.12
Jun-19	98.36	110.62	132.4
Jul-19	84.26	105.2	96.2
Aug-19	102.39	108.15	89.1
Sep-19	89.1	96.38	92.49
Oct-19	95.36	94.02	96.37
Nov-19	89.61	91.05	102.37
Dec-19	90.76	91.09	102.79
Jan-20	120.65	134.63	120.6

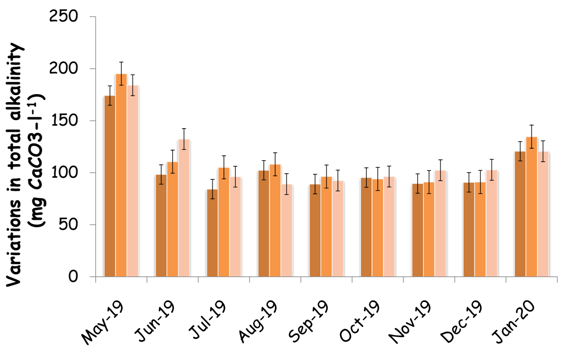

Fig 3. Variations in total alkalinity in different ponds (May, 2019-Jan, 2020)

Table 4. Variations in dissolved oxygen observed across the three ponds (P1, P2 and P3) during May, 2019 to January, 2020.

Month-Year	P1	P2	P3
May-19	6.60	6.40	6.50
Jun-19	6.20	6.30	6.40
Jul-19	6.00	6.10	6.00
Aug-19	6.40	5.90	6.70
Sep-19	7.10	7.20	7.10
Oct-19	6.90	6.80	7.10
Nov-19	6.50	6.80	6.20
Dec-19	6.50	6.30	6.40
Jan-20	7.40	7.20	7.30

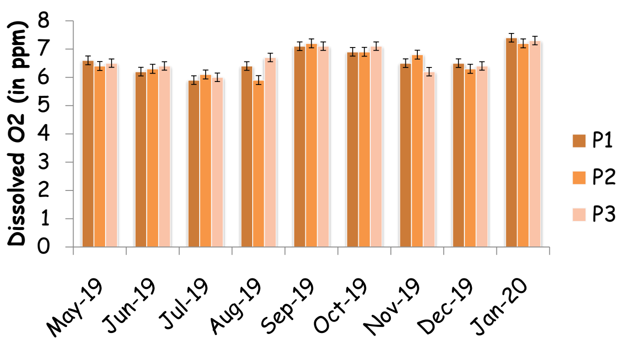

Fig 4. Dissolved oxygen (DO) in three ponds (in ppm) (May, 2019-Jan, 2020)

Table 5. Variations in nitrate-nitrogen (μg-l-1) observed across the three ponds (P1, P2 and P3) during May, 2019 to January, 2020.

Month-Year	P1	P2	P3
May-19	2.12	2.7	2.9
Jun-19	1.9	2.9	3.6
Jul-19	3.12	4.01	3.94
Aug-19	3.4	4.5	3.7
Sep-19	3.51	4.8	3.9
Oct-19	4.1	4.21	3.8
Nov-19	3.52	4.8	3.89
Dec-19	3.9	4.6	3.9
Jan-20	2.8	5.3	4.8

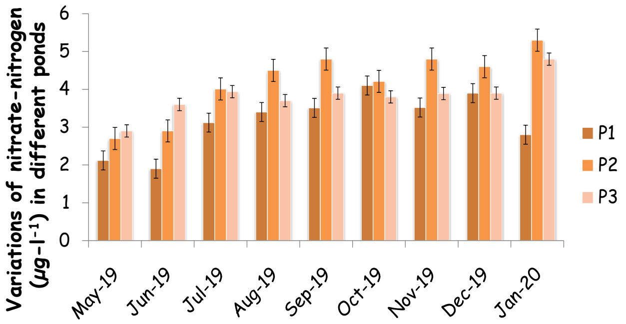

Fig 5. Variations of nitrate-nitrogen in different ponds (May, 2019-Jan, 2020)

The average yield of fishes and their cost at site was from P1-155 kg, from P2-133 kg and from P3-115kg @ Rs 120/kg and the total sale price was Rs. 48,360 and the net profit was 30,360 in the period under study (2019-2020) (Table 6). The profit of the fish sale was being used as seed money by the volunteers for cultivation of fish for livelihood besides other engagements. Thus the objectives have been achieved through training and interaction sessions generating confidence among the villagers for aquaculture for their livelihood.

Table 6: Post-harvestment output

Species	P1 (2100 Sq.ft)	P2 (1980 Sq.ft)	P3 (1590 Sq.ft)
Catla catla	51 kg	47 kg	42 kg
Labeo rohita	56 kg	42 kg	36 kg
Cirrhinus mrigala	48 kg	44 kg	37 kg
Total yield	155 kg	133 kg	115 kg
Sale price	18,600	15,960	13,800
Approx expenditure	6000	6000	6000
Profit (Indian rupees)	12,600	9,960	7,800

IV. CONCLUSION

Limnological parameters like dissolved O_2, pH, temperature, nitrate-nitrogen content, alkalinity was measured across three different ponds and finally fish farming was initiated. The pH was found to be between 7.4 to 7.9. The dissolved O_2 ranged in between 5.9 to 6.9. The temperature across the ponds ranged in between 19.4 to 34.3°C. Nitrate-nitrogen (μg-l^{-1}) and the total alkalinity (mg $CaCO_3$.l^{-1}) varied between 1.9 to 5.3 and 84.25 to 195.24 respectively. The ponds were stabilized and the people were empowered with the techniques for composite fish farming of Indian major carps (*Catla catla*, *Labeo rohita and Cirrhinus mrigal*) as candidates for harvesting.

Author contribution statement

Gagan Kumar Panigrahi and Pradip Kumar Prusty conceived the idea. Pradip Kumar Prusty, Yashaswi Nayak and Annapurna Sahoo performed the experiments. Gagan Kumar Panigrahi and Yashaswi Nayak analyzed the results. All the authors significantly contributed in preparing the manuscript.

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Conflict of interest

The authors declare that they have no conflict of interest.

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