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ASSESSMENT OF PHYSICOCHEMICAL PARAMETERS OF WATER IN AN INDUSTRIAL SCALE IN POND RACEWAY SYSTEM

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Abstract

The In-pond raceway system is a highly sophisticated innovative aquaculture technology. Many research has been done on the physicochemical characteristics of water. The present study was conducted to measure the physicochemical parameters of water in an In-Pond Raceway System (IPRS). The study employed standard and instrumental methods to investigate a range of physicochemical parameters, including water temperature, pH, DO, TDS, conductivity, ammonia, nitrite, and phosphate. One-way Analysis of Variance was conducted to calculate the variation of physicochemical parameters among the study sites. Statistical analysis showed there was no significant variation of physicochemical parameters ($p>0.05$) among the experimental sites except DO and ammonia ($p<0.05$). The experimental study showed that, all the key physicochemical parameters water in IPRS production zone were within the optimum ranges when compared with standard water quality parameters which is the prerequisite to introduce maximum survivability of fish production in IPRS system.

Keywords: In-Pond Raceway System, Dissolved oxygen, Total dissolved solid, Conductivity, Ammonia, Nitrite, Phosphate

Introduction

The In-Pond Raceway's (IPRS) basic idea is simple. As with cages, this method is adaptable to nearly any body of water, but it has the added benefit of controlled water movement, which enhances water quality and permits higher stocking densities, which raise overall production per unit area (Masser & Lazure, 1997). This 2–5% of the entire pond surface is dedicated to an intense culture area that includes multiple aquaculture raceways (Li et al., 2019). Water quality is determined by the aquaculture pond's physicochemical and biological factors, which impact the pond's production directly or indirectly (Moses, 1983). One of the most crucial aspects of water quality that affects aquatic species' metabolism, development, ability to consume food, reproduction, and other biological processes is water temperature (Moncrief & Jones, 1977). Fishes depend on physico-chemical properties like water temperature (WT), turbidity (TBD), power of hydrogen ion concentration (pH), dissolved oxygen (DO), free carbon dioxide (FCO), total alkalinity (TA), total hardness (TH), and nitrate-N (NO_3^-) (Lewis, 1999). One of the key elements of sustainable aquaculture is understanding physico-chemical properties because these are prerequisites for beginning fish farming in IPRS. One of the most important aspects of sustainable aquaculture is understanding its physico-chemical characteristics, since these qualities are necessary to begin fish farming in pond raceway systems (IPRS). Determining the physicochemical characteristics of water, including temperature, pH, DO, TDS, conductivity, ammonia, nitrite, and phosphate, in both standard pond culture and the Pond Raceway System is the objective of this study. A new technology for Bangladesh's aquaculture sector is the In Pond Raceway System (IPRS). In recent times, we've seen a shortage of land parcels where we may spread horizontally for aquaculture.

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As a result, the primary motivation for bringing this technology to our country is to expand aquaculture vertically in a more intense method. Because the productive lands are degrading day by day with growing population. Nowadays peoples are using their more land for residential issues moreover than agriculture. So, we require an alternative technology to meet the growing protein demand, such as a new intense approach to meet the demand for fish protein. IPRS opens opportunities to take the challenge. It can produce ten times better than an ordinary culture method by using minimum land. So, our country needs this technology for aquaculture production as well as industrial employment with restricted land utilization.

Materials and Method

Sample collection

The study was conducted in the In-Pond Raceway System (IPRS) and traditional pond at Afil Aqua Fish Ltd. Sharsha, Jashore. The water in all of the ponds was free of contaminants from outside sources and also fully exposed to the prevailing sunlight. The experiment was conducted from summer to late autumn season in 2022. Water sample collected from In Pond Raceway System and traditional pond at sharsha, Jashore to determine the physico-chemical parameters. The cultivable species were Rohu (*Labeo rohita*), Catla (*Labeo catla*), Magur (*Clarias batrachus*), Tilapia (*Oreochromis niloticus*) in IPRS and traditional pond.

Sample analysis

Samples were collected 4th times from summer to late autumn during morning from three stations (IPRS production zone, IPRS purification zone, and traditional pond) in order to analyze the physicochemical parameters. Samples of water were kept in 500 ml bottles and placed inside the cooler box. To be analyzed for ammonia and nitrite, water samples were kept in 0.3 ml of pure H_2SO_4. Water samples without preservation kept in the cooler box were tested for total phosphate. At Khulna University's Fisheries and Marine Resource Technology lab, water chemistry lab, several parameters were measured and evaluated, including temperature, pH, dissolved oxygen (DO), total dissolved solid (TDS), conductivity, ammonia (NH_3), nitrite (NO_2^-), and phosphate (PO_4^{3-}). Using a digital meter, the temperature of the water sample was determined. The pH of the water from the collected samples was measured using a benchtop digital pH meter. Prior to use, buffer solutions with pH values of 7 and 10 were used to calibrate this apparatus.

Before each pH reading, the electrode was properly washed with distilled water. During sample collection, a digital DO meter was used to measure the amount of dissolved oxygen (DO) in the water. Digital TDS and conductivity meters were used to measure the water's total dissolved solids (TDS) and conductivity following the collection of a water sample. We used the Nesslerization Method to measure the amount of ammonia nitrogen in the water. The Spectrophotometric Screening Method was utilized to quantify the nitrite content of the water. By using ascorbic acid, phosphate is measured.

Results

Water pH

During the study period pH values were not significant difference among in IPRS production zone, IPRS purification zone and traditional pond $p>0.05$. The pH was found to vary among different seasons. The maximum range of pH values was found in IPRS production zone during both the rainy season and late autumn, while the lowest rang of pH was found in IPRS purification zone during the summer season, as shown in Figure 1.

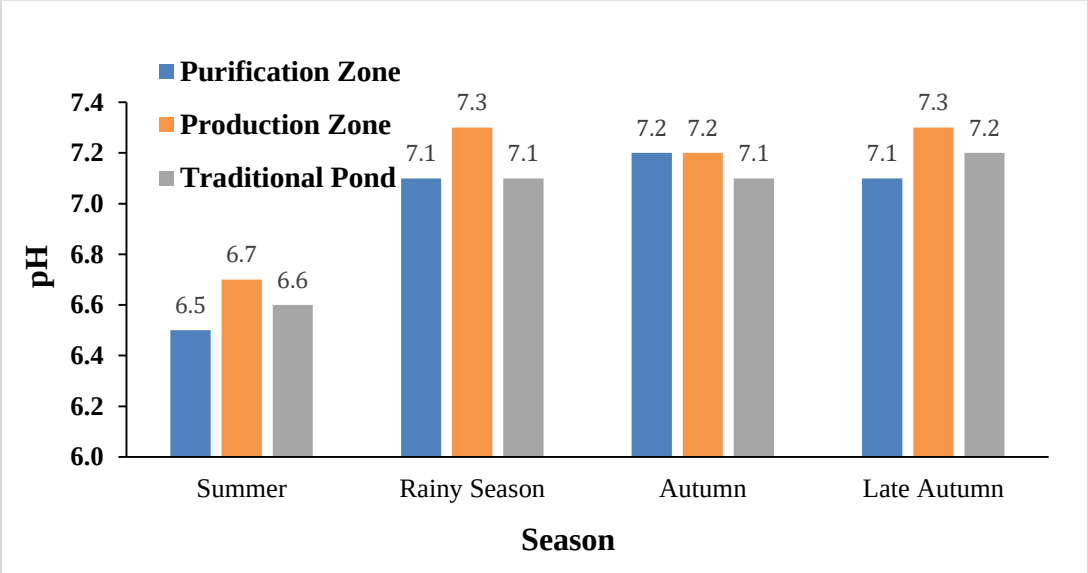

Figure 1. Changing pattern of water pH at different season

Dissolve Oxygen (DO)

The DO was measured and varied among each experimental group simultaneously and during various seasons. The range of DO readings varied significantly between traditional ponds, IPRS purification zone, and the IPRS production zone $p<0.05$. The maximum level of DO was found in IPRS production zone during both the rainy season and late autumn season where the minimum level of DO was found in traditional pond during summer Season (Figure 2).

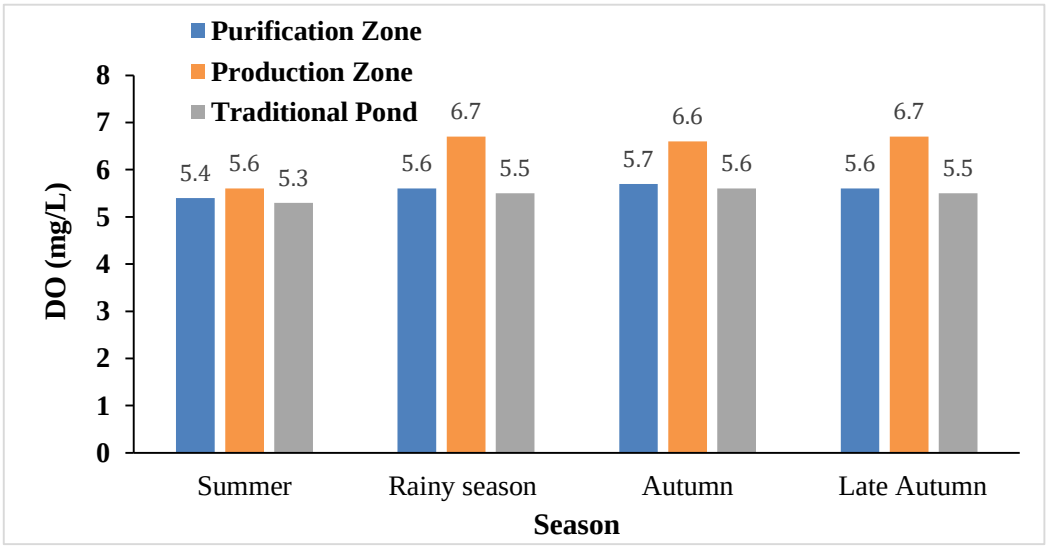

Figure 2. Changing pattern of DO various season

Temperature

The present study of temperature value was not found to significant difference among in IPRS production zone, IPRS purification zone and traditional pond $p>0.05$. In this study, highest temperature was measured in traditional pond

during summer season and the lowest temperature was found in IPRS production zone during rainy season (Shown in Figure 3).

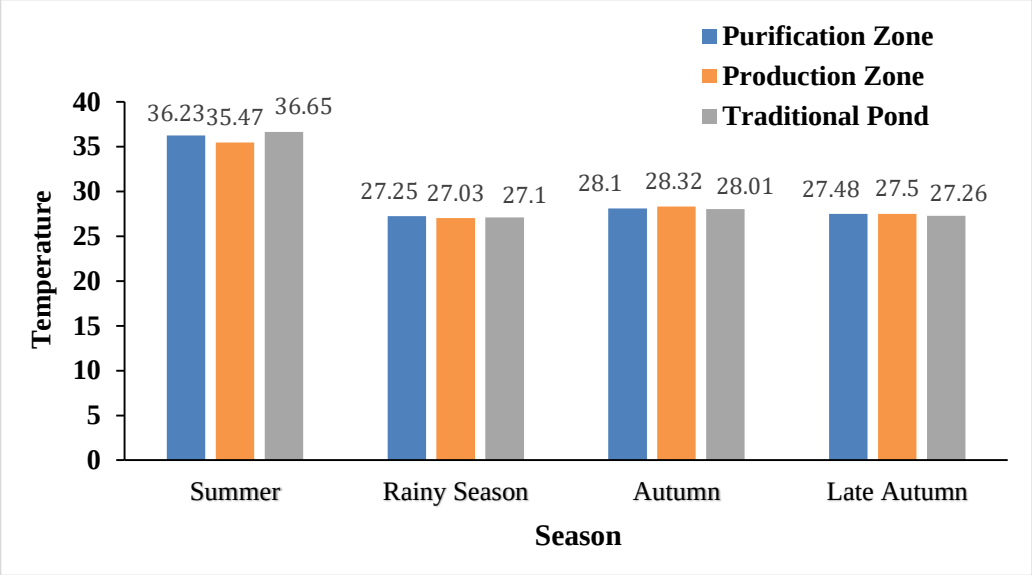

Figure 3. Variation of temperature at different season

Total Dissolved Solid (TDS)

The range of TDS values were not significant difference among in the IPRS production zone, IPRS purification zone and traditional Pond $p>0.05$. During the study period, the maximum range of TDS was showed in IPRS production zone during summer season and the minimum range of TDS was determined in IPRS production zone during rainy season, as shown in Figure 4.

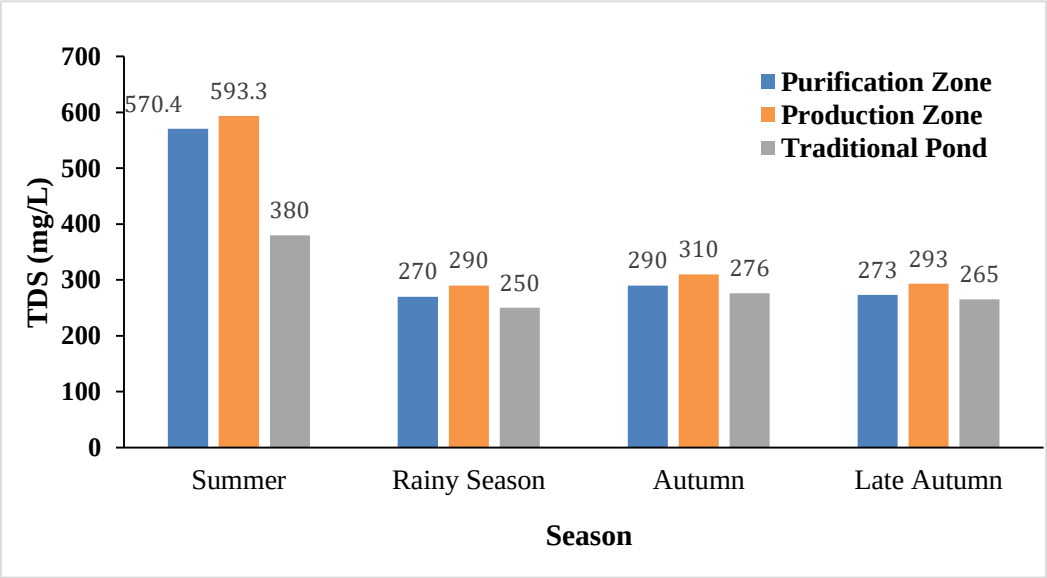

Figure 4. Changing range of Total Dissolved Solid (TDS) at various Season

Conductivity

The range of Conductivity readings among IPRS production zone, IPRS purification zone, and traditional Pond did not change significantly $p>0.05$. In this experiment period, the highest value of Conductivity was measured in IPRS production zone during summer season and the lowest value was measured in traditional pond during autumn season (Shown in figure 5).

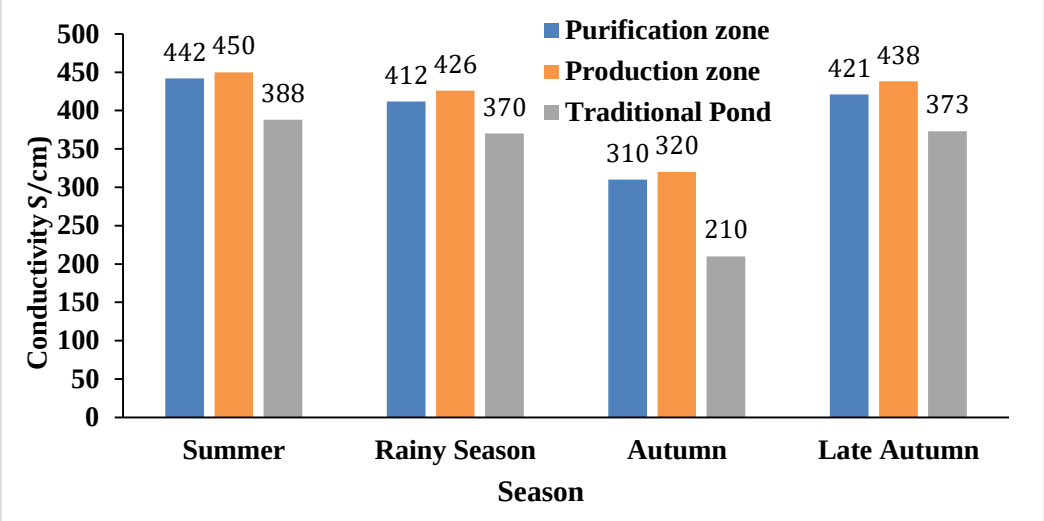

Figure 5. Variation of conductivity at different season

Ammonia

The NH_3 was found to vary among different experimental groups at the same time and in different seasons (Figure 6). The ranges of NH_3 values were significant difference among in the IPRS production zone, IPRS purification zone and traditional Pond $p< 0.05$. The highest value of ammonia was measured in IPRS production zone during late autumn season and the lowest value was measured in traditional pond during summer season, as shown in Figure 6.

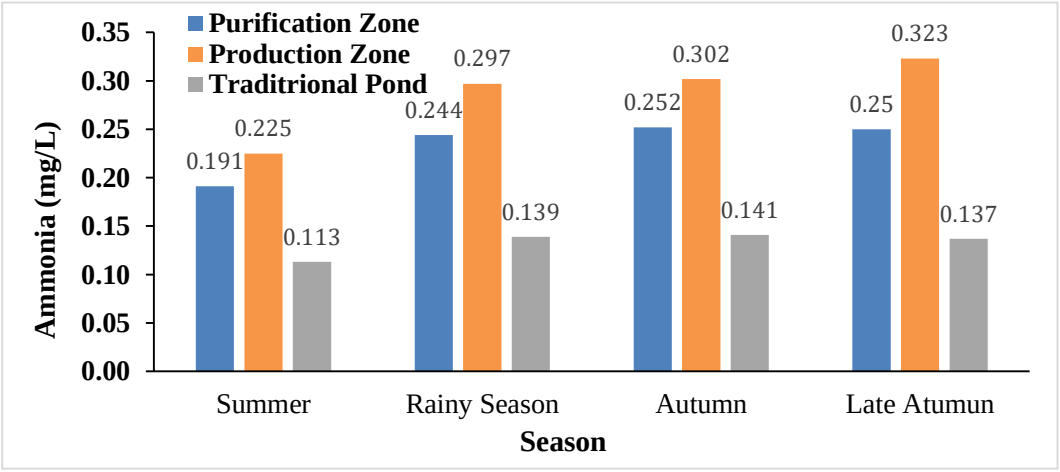

Figure 6. Changing range of ammonia at various season

Nitrite

The Nitrite (NO_2^-) showed no significance difference among in IPRS production zone, IPRS purification zone and traditional pond. During the study period, the maximum level of Nitrite (NO_2^-) was found in IPRS during late autumn season and the minimum level of Nitrite (NO_2^-) was found in traditional pond during summer season (Shown in Figure 7).

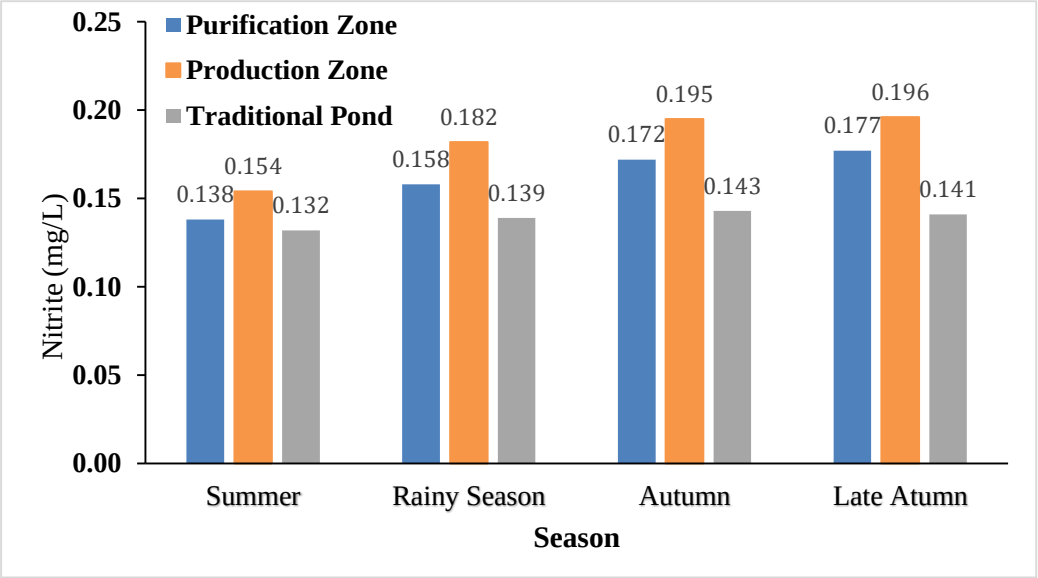

Figure 7. Changing pattern of nitrite at various season

Phosphate

The range of phosphate (PO_4^{3-}) readings did not vary significantly among traditional ponds, IPRS purification zone, and the IPRS production zone ($p > 0.05$). The experiment conducted that the maximum rang of phosphate (PO_4^{3-}) was found in traditional pond during both autumn and late autumn. And the lowest range of phosphate (PO_4^{3-}) was also found in traditional pond during Summer Season, as shown in Figure 8.

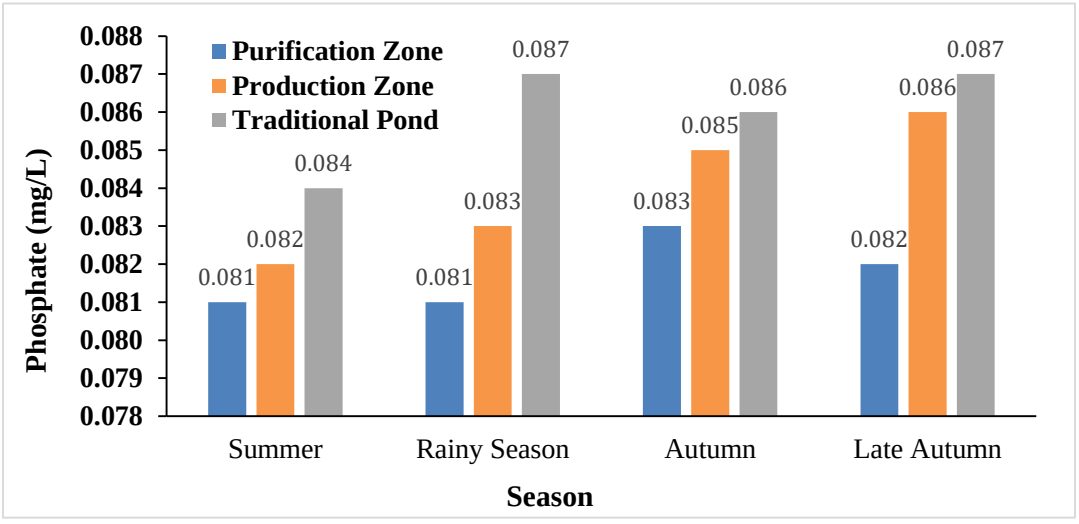

Figure 8. Changing pattern of phosphate at various season

Discussion

An aqueous solution's pH value indicates how basic or acidic it is. In technical terms, pH, or hydronium concentration as it is often expressed, is the negative logarithm of the acidity of the solved hydronium ion (Tucker & Abramo, 2008). The majority of freshwater organisms have evolved to withstand a rather wide ambient pH range, although the pH of freshwater ecosystems can vary significantly over course of a day and a season (Tucker & Abramo, 2008). The pH ranges of 4.6 to 6.5 and 9 to 11 exhibited stuttered development in the aquatic species, which are susceptible to stress (Ekubo & Abowei, 2011). According to Tucker and Robinson (1990), the optimum level of pH is (6-9) and the tolerated level of pH is (5-10) for catfish culture in Pond Raceway System. The present study of water pH was found to variation among experimental groups 6.5 to 7.3. Among all three experimental groups (IPRS production zone, IPRS purification zone, and conventional Pond), there was no significant variation in pH. The lowest pH value was measured from summer season. This may be caused by the temperature (pH decreases with increase in temperature). In aquaculture, one of the most crucial variables is DO. In order to enhance productivity in tropical aquaculture ponds, Saloom & Duncan (2005) recommend maintaining the DO concentration at 5 ppm. For catfish in the Pond Raceway System, Tucker and Robinson (1990) found that the tolerated range of DO is 2.0 mg/l and the optimal range is between 5 and 15 mg/l. Better productivity is desirable for DO content above 5 ppm (Banerjea, 1967). The level of DO in groups of the experiment (IPRS production zone, IPRS purification zone, and traditional pond) is suitable for good production of aquaculture. The maximum DO was found in IPRS production zone. The reason for this is that the IPRS has an airlift pump that provides aeration in the IPRS production zone. In aquatic ecosystems, water temperature has a significant role in influencing biological processes. Water temperature has an important influence on all physiological and metabolic functions as well as life activities in aquatic species, including consuming food, reproduction, mobility, and distribution (Manickam, 2015). According to Tucker and Robinson (1990) the optimal level of water temperature is (27-29) and the tolerated level is (0-40) for catfish in Pond Raceway System. The water temperature was found to vary among experimental groups 27.030C to 36.650C which was suitable for IPRS. The maximum data of temperature was found in summer season. The amount of dissolved solids in water is indicated by the term total dissolved solids. The amount of inorganic contamination in a water system is referred to as "total dissolved solids" (Usha et al., 2008). A varied fish population can have total dissolved solids (TDS) up to a maximum of 400 mg/L, according to APHA (2005).

The total dissolved solid was found higher in summer season than other Seasons. TDS is directly related to conductivity, conductivity increases as the temperature increase, eventually affecting TDS. So, the value of TDS was high in summer season. The higher readings observed during the summer could be the result of ions building up as a result of biological turnover, evaporation, and contact with sediments. These results concur with Payne's (1986) assertion. Additionally, according to APHA (2005), conductivity in inland fresh water outside of the range of 150 to 500 µs/cm indicates that the water is unsuitable for macro-invertebrates or specific fish species. The value of conductivity was found to vary among the experimental groups 450 to 210 µs/cm which was suitable for Aquaculture. The maximum value of conductivity was found during summer season. This may be caused by the temperature (Conductivity increases with increase in temperature). Ammonia plays an important part within the nitrogen cycle of any aquatic environment. According to Chen (1988), pond fish culture can tolerate an ammonia level in the water of the pond that was less than 1 mg/l. Less than 0.05 mg/l is safe for fresh water fish culture system (Lawson, 1995). Ammonia level showed significant difference among the experimental groups (production zone, purification zone and traditional Pond) 0.323 mg/l to 0.113 mg/l. The ammonia level always showed high in the IPRS production zone for every sampling. This may be occurred due to the large amount of nitrogenous waste excreted in IPRS cell or production zone. Because IPRS is a high-stocking density fish culture system that uses a lot of formulated feed. This study's ammonia results are more or less similar to those reported by Ali and Baggs (1982), in which ammonia nitrogen levels ranged from 0.2 to 0.37 mg/l. As a result, the ammonia-nitrogen value in the current study's experimental rearing systems was appropriate for rohu culture. Nitrite is an intermediate product of the aerobic nitrification process. Since nitrite can be extremely harmful to aquatic life, Stone and Thomforde (2004) state that the optimal nitrite concentration range for fish culture is between 0 and 1 ppm, while a range below 4 ppm is also tolerable. According to Tucker and Robinson suggest that the optimum level of nitrite is 0 mg/l and the tolerate level is depends on chloride concentration. The maximum level of Nitrite was found in IPRS production zone of every season and all the groups of data were suitable for aquaculture. The rate at which nitrogen is converted into microbial protein increases with the

addition of carbon, which ultimately results in a reduction in nitrogenous waste (Kuhn et al., 2010). But higher rate of feeding (formulated feed) for higher stocking density in IPRS production zone increased the amount of nitrite. Phosphate is an important nutrient for the maintenance of fertility of water body. n an aquatic environment, it is crucial for photosynthesis. However, a high phosphorus concentration may result in an overwhelming algal bloom. The tolerable range of phosphorus in an aquaculture pond is 0.03 to 2 ppm, whereas the desired range is 0.01 to 3 ppm and also stated that concentrations beyond 3 ppm will stress aquatic species (Bhatnagar & Devi, 2004). In this study the phosphate was found higher in IPRS production zone every season; because the high stocking density leaded to consume the existing phytoplankton and so the photosynthesis level was also reduced. For this reason, the remaining phosphate was unused and the level was of it was increased. But there was no significant difference in phosphate between other experimental groups (IPRS production zone, IPRS purification zone, and traditional pond).

Conclusion

The goal of the current study was to assess the water's physicochemical properties in the Pond Raceway System. Through the study there was no significance variation of physicochemical parameters of water among the experimental sites except DO and ammonia. All the physicochemical parameters were within the optimum range and suitable for fish production.

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Conflict of interest

The authors declare no conflict of interest.

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