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(RESEARCH ARTICLE)

Physicochemical and Microbiological Evaluation of Surface Water Quality of Aquaculture Ponds Located in Savar, Dhaka, Bangladesh

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Abstract

Aquaculture is one of the most vital sectors in Bangladesh as it exhibits a major role in nutrition, livelihoods and foreign exchange earnings every year. Aquaculture in our country is highly impacted and presently triggering serious health risks due to chemical impurities, infectious diseases caused by pathogenic microorganisms and heavy metal accumulation. The industrial sewages and wastes likewise deteriorate severely the water quality and aquatic ecosystems of ponds, rivers, lakes and various waterways located in Savar, Dhaka, as this area is located within one of the major industrial zones in Bangladesh. In the current investigation, water samples were collected from the five selected ponds situated in Atomic Energy Research Establishment (AERE) premises, Savar, Dhaka and water quality assessment was done by analyzing different physicochemical and microbiological parameters according to the standard procedures. The acquired values for pH, temperature, salinity, total alkalinity (TA), total dissolved solids (TDS), electrical conductivity (EC), total hardness (TH), chloride content, free CO_2, dissolved oxygen (DO), nitrate ion and sulfate ion were compared with the recommended standard values of Bangladesh and WHO guideline for suitable water quality. Some of the physicochemical parameters showed values lower than the standards for pond water that are inappropriate for aquaculture. Total viable count, total coliform and fecal coliform count were found to be higher than the guideline values of WHO indicating fecal contamination of the water. Various pathogens which can cause fish infections and diseases were also isolated from the ponds. Water quality index (WQI) was calculated for five sampling sites to determine the level of pollution and it was observed that the water quality of all the ponds reached to critical point of pollution. The results revealed that the pond waters of five different sites were excessively polluted and unsuitable for fish culture.

Keywords: Aquaculture; Pollution; Physicochemical parameters; Bacteriological assessment; Water quality index

1. Introduction

Bangladesh is one of the resourceful countries with its extensive range of aquatic bio-diversities and world's leading inland fisheries. It has huge water resources all over the country in the form of small ponds, ditches, lakes, canals, small and large rivers, and estuaries covering about 4.34 million hectares (1). Aquaculture and fisheries in Bangladesh are the most important potential sectors of the national economy, accounting to 3.69% of national GDP, 23.12% of agricultural GDP and 2.09% of foreign export earnings (2). Prospective progress in fisheries is more visible than many other sectors. Fish is the second most valuable agricultural crop in Bangladesh and its production contributes to the livelihoods and employment of millions of people according to the department of fisheries, Bangladesh. The total fish production in Bangladesh in the fiscal year 2013-14 was estimated as 3.55 million tons, of which 1.96 million tons (55.15%) were obtained from inland aquaculture, 0.99 million tons (28.07%) from capture fisheries and 0.60 million tons (16.78%)

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from marine fisheries (2). Bangladesh ranked 5th position in leading aquaculture producing countries in the world just after China, India, Vietnam and Indonesia (3). Bangladesh produced 30,61,687 mt fish in 2011 of which 15,23,759 mt i.e. 49.76% was produced by the aquaculture sector. Bangladesh contributed 2.43% in world total aquaculture production in 2011 (3). Pond culture represents the mainstay of aquaculture in Bangladesh, accounting for 85.8% of the total recorded production and 57.7% of the area under culture (4). As fish is an important component of human foods and animal feeds, fish cultivation is therefore a necessity in order to meet the protein demand of the ever increasing populace in our country. About 10% of our population is dependent directly and indirectly on the fisheries for their living (5). Hence the need for sustainable development through proper management of fishery is now a necessity in the context of the high demand for fish as a relatively cheap source of animal protein. Fish supplements to about 60% of our daily animal protein intake (6)(7).

Water is the most important resource for aquaculture and can be a significant source for contamination. The conditions that fishes are cultured may be potentially stressful, causing existing infections to become more severe and precipitate disease outbreaks which may also compromise the suitability of such fish for human consumption. The mortality of fish due to disease and water pollution constitutes problems to aquaculture development (8). Therefore, for a successful aquaculture venture, maintenance of water quality is very important. Because, the availability of good quality water is an indispensable feature for fish survival and for their diversity. Moreover, successful aquaculture and fisheries projects are dependent on several physical, chemical, biological and microbiological conditions that exist in watercourses. The relationship between the fish, their biotic and abiotic environments is not an isolated phenomenon; changes of one may reflect and affect the other. Fishes are also dependent on water and atmospheric temperature, pH, dissolved oxygen, alkalinity, salinity, BOD (biological oxygen demand) and some salts for growth and development. The distribution and size of fish populations are largely determined by the interaction of the fish with the immediate environment which directly impact on pond water quality and indirectly on the whole ecosystem. More so, the placing of fish in fish ponds may expose them to new pathogens. Great loss of fish has been attributed largely to bacterial infections (9).

Additionally, various industrial, municipal, agricultural wastes contaminate the water beyond human consumption and are often responsible for surface water contamination that disrupt the ecosystems and create hazards for aquaculture. The Savar, a rapidly growing urban area of Dhaka, is one of the major industrial zones in Bangladesh. Country's second largest Dhaka Export Processing Zone (DEPZ) is located in Savar. Furthermore, there are numerous industrial sites along the Dhaka-Aricha Highway. All these industrial activities severely deteriorate water quality of the rivers, lakes, waterways, and wetlands that are either inside or adjacent to Savar industrial areas, thus posturing dreadful risks to human health and the environment of the area. For this reason, an investigation was conducted to evaluate the physicochemical and microbiological parameters of fishing pond water, collected from various sites of Atomic Energy Research Establishment Area (AERE), Savar. The investigation was aimed to determine the physicochemical properties, the load of microbial pathogens, to identify some fish pathogens and also to determine the water quality index of the fishing ponds of Savar.

2. Material and methods

2.1. Sampling site and water sample collection

Water samples were collected from five selected ponds in Atomic Energy Research Establishment (AERE) premises, Savar, Dhaka. Sampling was performed after ensuring the cleanliness of hands and equipment. Before collecting samples, sample containers were cleaned by detergent solution and then it was treated with 5% HNO3 acid overnight and finally washed with de-ionized water and dried in oven. Followed by repeated washing with sample water to avoid contamination, all the samples were taken with grab sampling. The samples were sealed with Teflon lined caps to avoid any type of exchange with environment. After sampling, the containers were kept in air tight condition and labeled properly for identification as DG, NIB (1). NIB (2), TC (1) & TC (2) according to the location site of the ponds in the AERE area. The collected water samples were then immediately brought into the laboratory for physicochemical and bacteriological analysis. An appropriate amount of water samples were preserved following the standard procedure of American Public Health Association (10).

2.2. Assessment of physicochemical properties

Physicochemical parameters such as the pond water color were assessed by visual observation and smell or odor was observed by the nose through sniffing. Temperature and pH of the water samples were recorded utilizing portable laboratory thermometer (Mercury 305 MM thermometer, Zeal, England) and pH meter (HI 2002-02, Hanna instruments, Romania) respectively. Temperature was measured in degree Celsius, and the pH was calibrated with standard buffer solution.

Salinity, total dissolved solid (TDS), Electrical conductivity (EC) of the pond water samples were measured by HI-2003 Edge® Conductivity meter – Hanna Instruments (HI 2003-02, Romania). Conductivity was measured in µs/ cm by dipping the electrode into a Falcon tube filled with pond water sample. The specific conductivity of the water correlates with the concentration of dissolved minerals which are the total dissolved solids of the sample. A digital multi range instrument (Model HANNA HI 2003-02, Romania) was used to measure salinity in parts per thousand (ppt) or in percentage (%) from pond water. Dissolved oxygen (DO) of pond water was measured by a dissolved oxygen meter immediately after sample collection, following standard methods. Chloride content, free CO_2 ,total hardness (TH) and total alkalinity (TA were determined by the titrimetric method. The concentrations of sulfate ion and nitrate ion were determined by using UV-Visible spectrophotometer (T60UV-Visible Spectrophotometer, PG instruments) following the standard procedure of American Public Health Association (10). Measurement is based on comparison of absorbance of sample with a calibration curve of standard solution.

2.3. Water Quality Index (WQI)

Water quality index (WQI) is a dimensionless number that combines multiple water quality parameters into a single number by normalizing values to subjective rating curves (11). Conventionally, it has been used for evaluating the quality of water from different water resources such as ponds, rivers, streams and lakes. WQI is a single value indicator to the water pollution, which integrates the data pool generated after collecting due weights to the different parameters. Several researchers have worked on this concept and presented examples with case scenarios in the literature (12)(13).

Accordingly, WQI was calculated to determine the overall quality of the pond water from five sampling sites in Atomic Energy Research Establishment, Savar. Several parameters (total nine parameters) like pH, TDS, EC, Total Alkalinity, Total hardness, chloride, DO, nitrate and sulfate ions were considered to find out the WQI of the water (14).

2.4. Microbiological Analysis of water samples

The presence of the Total Viable Count was determined by standard plate count (SPC) using nutrient agar media employing pour plate technique (15). To determine the total coliform count and fecal coliform count, the most probable number method (MPN) was employed following the standard procedures (10). The total count was multiplied by the respective dilution factor to get the result. The calculated result was expressed as colony forming unit (cfu/ml) per ml of water.

2.5. Isolation and Identification of pathogens from water samples

The isolation and identification procedures of microorganisms were carried out on the basis of standard microbiological methods. For isolation of the pathogenic bacterial isolates, serial dilution plating method by was employed using nutrient agar (NA) as growth media. Colonies with distinct morphologies were then separated and purified by repeated streaking on NA media. Finally, purified bacterial isolates were transferred on agar slants and preserved for identification. Aliquots from MPN analysis tubes showing characteristics or features of presence of coliform and fecal coliform were transferred to streak plates containing Mac Conkey Agar (MCA), Brilliant Green Agar (BGA) and Bismuth Sulfate Agar (BSA) medium. The colonies exhibiting growth characteristics of coliform and fecal coliform on the mentioned media were isolated and purified. Bacterial isolates including coliform and fecal coliform bacteria were analyzed using the standard cultural, morphological, physiological and biochemical characteristics. The isolates were then identified up to species based on the critical comparison of the observed characteristics with the description of bacterial strains given in Bergey's Manual of Determinative Bacteriology, 8thed (16).

3. Results

3.1. Physicochemical properties

A number of physicochemical parameters were investigated to assess the water qualities of five ponds, located in AERE, Savar, Dhaka. The Sample coding, numbering and labeling are indicated in table 1.

The color and the odor indicate the initial status of water. So, at first, the colors of the water were observed visually from the five sampling sites (Figure 1). The abundance of phytoplankton and zooplankton are responsible for the determination of colour of an aquatic body and green, bluish green/ brown greenish color of water that indicate good plankton population which are good for fish health (17). The obtained result for colors is shown in table 2. The water of all the sampling sites were odorless.

Figure 1 Different Sampling Sites of AERE

Table 1 Sample coding, numbering and labeling

Sample No.	Sample ID	Location
1	DG	D.G. office
2	NIB (1)	NIB (near left side of DG office)
3	NIB (2)	NIB (near right side of DG office)
4	TC (1)	Training Centre (near left side)
5	TC (2)	Training Centre (near right side)

Table 2 Water color of five different sampling sites of Savar

Water samples	Color
DG	Light greenish
TC (1)	Light greenish
TC (2)	Turbid
NIB (1)	Greenish
NIB (2)	Greenish

Different other major physicochemical parameters were also determined to assess the quality of pond water of the five sampling sites and assembled in Table 3.

Table 3 Physicochemical parameters of the pond water body

SL. No.	Parameters	Sample1 (DG)	Sample 2 (TC1)	Sample 3 (TC-2)	Sample 4 (NIB-1)	Sample 5 (NIB-2)	Standard Limit
1	pH	7.46	7.67	7.15	7.37	7.32	6.5-8.5
2	Temperature (°C)	27.6	26.25	26.0	26.03	26.7	20-30
3	Electrical conductivity (μs/cm)	249	159	161.7	250	110	300
4	TDS (mg/L)	124.8	79.5	80.9	125.3	55.4	500
5	Total Alkalinity (mg/L)	55	38.5	35.75	49.5	27.5	120
6	Total Hardness (mg/L)	108	68	56	100	42	300
7	Chloride (mg/L)	21.3	23.075	17.75	19.52	19.525	250
8	Nitrate (mg/L)	1.5180	1.659	2.7260	1.5070	1.030	45
9	Sulphate(mg/L)	3.9140	4.2	8.1950	0.7760	8.3280	150
10	Dissolved oxygen (mg/L)	1.6	1.9	2.1	1.5	1.1	5.00

The pH of natural water is greatly influenced by the concentration of carbon dioxide which is an acidic gas (18) and increases the amount of acidity that affects fish culture. That is why, pH value was determined. The pH values obtained in the study ranged from 7.15 to 7.67 (Table 3). The change of temperature affects the metabolism and physiology and ultimately affects the fish culture and production. The results obtained from the study showed temperature values ranging from 26 to 27.6°C (Table 3). Fishes are sensitive to the salt concentration of their waters that affects the density and growth of aquatic organism's population (19). In this research work, the salinity values ranged from 0.2 to 0.5% and the free CO_2 values obtained ranged from 1.27 to 1.68 mg/L, that are not shown in the table. The TDS values ranged from 55.4 to 124.8 mg/L. Conductivity of water depends on its ionic concentration (Ca^{2+}, Mg^{2+}, HCO_3^-, CO_3^-, NO_3^- and PO_4^-), on temperature and on variations of dissolved solids. High values of conductivity are an indication of pollution. The conductivity values of pond water in the study ranged from 110 to 249 μs/cm. The total hardness of water is the parameter used to describe the effect of dissolved minerals (mainly Ca^{2+} and Mg^{2+}) which is attributed to the presence of bicarbonates, sulphates, chlorides and nitrates according to Ezekiel 2011(20). So, this parameter has a great importance for fish culture. Total hardness ranged from 42 to 102 mg/L in the investigation. The alkalinity of the samples were also determined and it ranged from 27.5 to 55 mg/L . The dissolved oxygen (DO) values obtained from this study ranged between 1.1 to 2.1 mg/L . Nitrate values ranged from 1.030 to 2.7260 mg/L. Sulphate is known as one of the least toxic anions. Sulphate may occur in water as a result of industrial discharge. Water samples investigated had sulphate values ranging from 3.914 mg/L to 8.328 mg/L.

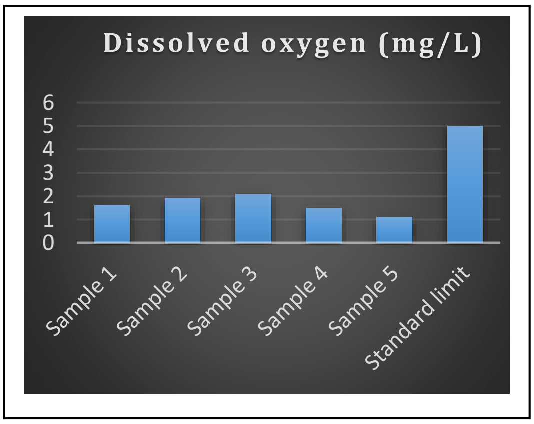

Figure 2. Dissolved oxygen (DO) values of five different samples.

Among the physicochemical parameters, the dissolved oxygen (DO) values (1.6, 1.9, 2.1, 1.5 and 1.1 mg/L in sample 1, sample 2, sample 3, sample 4 and sample 5 respectively) were below the permissible limits of pond water, which is shown in figure 2. Therefore, In the current study, almost all the physicochemical parameters were in the range of standards except the dissolved oxygen of the pond waters.

3.2. Variation of WQI in pond water

The present study used a simple modified WQI (14) considering local environments and hydrology of the pond water in AERE area to determine the pollution load and its suitability for various purposes. In this study, for the calculation of water quality index, nine important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). The weighted arithmetic index method (Brown et al, 1999) has been used for the calculation of WQI of the Waterbody. Further, quality rating or sub index (q_n) was calculated using the following expression;

$q_n = 100[V_n - V_{io}] / [S_n - V_{io}]$

(Let there be *n* water quality parameters and quality rating or sub index (q_n) corresponding to n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value)

Where, q_n = quality rating for the nth water quality parameter
V_n= Established value of the n^{th} parameter at a given sampling station
S_n= standard permissible value of the nth parameter
V_{io}= Ideal value of the nth parameter in pure water. (*i.e.*, 0 for all other parameters except the parameter pH and Dissolved oxygen (7.0 and 14.6 mg/l respectively)

Unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter

$W_n = K/S_n$

The overall WQI was calculated by aggregating the quality rating with the unit weight linearly

$WQI = \sum Wnqn / \sum Wn$

The correlation of water quality index level and water quality status is mentioned in Table 4.

Table 4 Water quality index (WQI) and status of water quality according to Chatterji and Raziuddin (21)

Water quality index level	Water quality status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

In the current investigation, the WQI were calculated for five different samples and mentioned in the Table 5.

Table 5 Variation of WQI values of five water samples showed in table 5a,5b,5c,5d and 5e.

Table-5a (WQI of Sample 1)

No	Parameters	Observed values (S_n)	Standard values (S_n)	Unit weight (W_n)	Quality rating (q_n)	W_nq_n
1	pH	7.46	6.5-8.5	0.2190	30.67	6.72
2	Electrical conductivity	249	300	0.371	83	30.79
3	Total dissolved solids	124.8	500	0.0037	24.96	0.092
4	Total Alkalinity	55	120	0.0155	45.83	0.71
5	Total Hardness	102	300	0.0062	34	0.21
6	Chloride	21.3	250	0.0074	8.52	0.06
7	Nitrate	1.5180	45	0.0412	3.37	0.14
8	Sulphate	3.9140	150	0.01236	2.61	0.03
9	Dissolved oxygen	1.6	5.00	0.3723	135.42	50.42
				ΣW_n=1.05	Σq_n=368.38	ΣW_nq_n=89.172
				Water Quality Index= $\Sigma W_nq_n / \Sigma W_n$=84.93		

Table-5b (WQI of Sample 2)

No	Parameters	Observed Values (S_n)	Standard Values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1	pH	7.67	6.5-8.5	0.2190	44.67	9.78
2	Electrical conductivity	159	300	0.371	53	19.67
3	Total dissolved solids	79.5	500	0.0037	15.9	0.06
4	Total Alkalinity	38.5	120	0.0155	32.08	0.49
5	Total Hardness	68	300	0.0062	22.67	0.14
6	Chloride	23.075	250	0.0074	9.23	0.068
7	Nitrate	1.659	45	0.0412	3.69	0.15
8	Sulphate	4.2	150	0.01236	2.8	0.034
9	Dissolved oxygen	1.9	5.00	0.3723	127.29	47.39
				ΣW_n=1.05	Σq_n=311.33	ΣW_nq_n=77.78
				Water Quality Index= ΣW_nq_n / ΣW_n=74.08		

Table-5c (WQI of sample 3)

No	Parameters	Observed Values (S_n)	Standard Values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1	pH	7.15	6.5-8.5	0.2190	10	2.19
2	Electrical conductivity	161.7	300	0.371	53.9	19.99
3	Total dissolved solids	80.9	500	0.0037	16.18	0.06
4	Total Alkalinity	35.75	120	0.0155	29.79	0.46
5	Total Hardness	56	300	0.0062	18.67	0.12
6	Chloride	17.75	250	0.0074	7.1	0.05
7	Nitrate	2.7260	45	0.0412	6.06	0.25
8	Sulphate	8.1950	150	0.01236	5.46	0.07
9	Dissolved oxygen	2.1	5.00	0.3723	100	37.23
				ΣW_n=1.05	Σq_n=247.16	ΣW_nq_n=60.42
				Water Quality Index= ΣW_nq_n / ΣW_n= 57.5		

Table-5d (WQI of sample 4)

No	Parameters	Observed Values (S_n)	Standard Values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1	pH	7.37	6.5-8.5	0.2190	24.67	5.40
2	Electrical conductivity	250	300	0.371	83.33	30.92
3	Total dissolved solids	125.3	500	0.0037	25.06	0.09
4	Total Alkalinity	49.5	120	0.0155	41.25	0.64
5	Total Hardness	100	300	0.0062	33.33	0.21
6	Chloride	19.52	250	0.0074	7.81	0.06
7	Nitrate	1.5070	45	0.0412	3.35	0.14
8	Sulphate	0.7760	150	0.01236	0.52	0.006
9	Dissolved oxygen	1.5	5.00	0.3723	136.46	50.80
				ΣW_n=1.05	Σq_n=355.78	ΣW_nq_n=88.27
				Water Quality Index= ΣW_nq_n / ΣW_n=84.07		

Table-5e (WQI of sample 5)

No	Parameters	Observed Values (S_n)	Standard Values (S_n)	Unit Weight (W_n)	Quality Rating (q_n)	W_nq_n
1	pH	7.32	6.5-8.5	0.2190	21.33	4.67
2	Electrical conductivity	110	300	0.371	36.67	13.6
3	Total dissolved solids	55.4	500	0.0037	11.08	0.04
4	Total Alkalinity	27.5	120	0.0155	22.92	0.35
5	Total Hardness	42	300	0.0062	14	0.09
6	Chloride	19.525	250	0.0074	7.81	0.06
7	Nitrate	1.030	45	0.0412	2.29	0.09
8	Sulphate	8.3280	150	0.01236	5.56	0.07
9	Dissolved oxygen	1.1	5.00	0.3723	140.63	52.35
				ΣW_n=1.05	Σq_n=	ΣW_nq_n=71.32
				Water Quality Index= ΣW_nq_n / ΣW_n=67.92		

3.3. Microbiological properties of the pond water

Water bodies usually consist of a wide variety of microorganisms, some of which are pathogenic and some of which are not. Some of the non-pathogenic microorganisms may lead to problems in water supplies such as unpleasant taste and odor which may serve as indicator of safety. The principal concern for microbiological quality of water, however, is the potential of contamination by pathogens. Such pathogenic contaminants include bacteria, helminths, protozoa and viruses and most of these organisms are derived from feces (22). Indicator organisms, usually bacteria, are practically used to analyze the microbiological quality of drinking water. Among such indicators the most commonly ones are thermotolerant (fecal) coliforms or *E. coli*. In addition to the above mentioned indicators of bacteriological water quality, the broader groups of coliforms known as total coliforms are also used in monitoring the water quality program (WHO 1995) (23). In addition, the fecal pollution or contamination can generate a significant threat to the entire aquatic ecosystem of the ponds along all other water bodies and the consumers.

Microbiological quality of water is therefore a critical parameter to measure health risks, as contaminated water is a key source of various infectious diseases. So, microbial count of water can often be considered as one of the important criteria to assess the water quality. So, to determine the microbiological contamination of pond water, it is vital to evaluate the total viable count (TVC), total coliform count (TCC) and total fecal coliform count (TFC). Hence, the pond waters were tested to detect the presence of coliform and fecal coliform including other pathogenic bacteria in the pond water. Microbiological analysis of pond waters in our study is shown in table 6.

Table 6 Bacteriological analysis of different pond water samples

Samples	Total viable count (TVC)	Total Coliform Count (TCC)	Total Fecal coliform Count (TFC)
Sample 1 (DG)	2.5×10^7 CFU/ml	1.2×10^3 CFU/ml	1.0×10^3 CFU/ml
Sample 2 TC (1)	1.8×10^5 CFU/ml	2.4×10^3 CFU/ml	2.9×10^4 CFU/ml
Sample 3 TC (2)	3.1×10^5 CFU/ml	1.6×10^3 CFU/ml	1.3×10^4 CFU/ml
Sample 4 NIB (1)	1.3×10^6 CFU/ml	1.1×10^3 CFU/ml	1.7×10^4 CFU/ml
Sample 5 NIB (2)	1.7×10^4 CFU/ml	2.4×10^3 CFU/ml	1.1×10^4 CFU/ml

3.4. Identification of pathogens

The microorganisms isolated and identified up to species from the ponds were *E. coli, Salmonella typhi, Staphylococcus aureus, Klebsiella pneumoniae* which may pose a threat to the of the aquatic ecosystem, health of fishes and consumers.

4. Discussion

The main goal of the present study was to analyze different physicochemical and microbiological parameters of water from five selected ponds of Savar with a view to determining the suitability of pond water for fish culture. According to Meade, physicochemical parameters such as alkalinity, dissolved oxygen, total hardness, pH and temperature are the most common water quality characteristics that will influence fish health and growth (24). The changes of temperature might cause variation in water density, salinity and dissolved oxygen. For sustaining aquatic life, the temperature range should be within 20 to 30°C. In our study, the temperatures for five different samples were ranged between 26-27.6°C. Hence, the investigated temperatures were within the permissible limit for aquaculture. According to Meade (24), the recommended pH for aquaculture ranges from 6.5 to 8.0. The results in our investigation were within this similar pH ranges (7.15 to 7.67). The results were also agreed by other workers (25). So, it was estimated that the ponds have suitable pH ranges for fish culture. A maximum value of 400 mg/L of total dissolved solids (TDS) is permissible for diverse fish population. In this analysis, the TDS values of water samples ranged from 55.4 to 125.3 mg/L ,which were within the acceptable limit of aquaculture. According to APHA (10), conductivity outside the range between 150 and 500 µs/cm of inland fresh water indicate that the water is not suitable for certain species of fish or macro-invertebrates. So, in our study, the conductivity of waters were within preferable range. DoF (Department of fisheries) reported that the range of dissolve oxygen suitable for fish culture is from 5 mg/L to 8 mg/L (26). DO is the measure of the amount of gaseous oxygen dissolved in an aqueous solution. Natural waters are saturated with dissolved oxygen in equilibrium with air. The concentration at this saturation is known to decrease due to increase in temperature, increase in salinity, low atmospheric pressure, high humidity, high concentration of submerged plants, plankton blooms. As a result, this change affects the growth, survival, distribution, behavior and physiology of aquatic organism (27). Therefore, obtained DO values (1.6, 1.9, 2.1, 1.5 and 1.1 mg/L in five samples) lower than the acceptable range indicated that the waters were not fit for fish culture. According to Ekubo and Abowei), the ideal level of CO_2 in fishponds is less than 10 mg/L (28). Consequently, the ponds (free CO_2 ranged from 1.27 to 1.68 mg/L) were agreeable for fish culture. The alkalinity values in the pond waters were found 55, 38.5, 35.6, 49.5 and 27.5 mg/L respectively for five samples that were the permissible limit of aquaculture according to

Bhatnagar and Devi, 2013 (29). The concentration of hardness ranged from 42 to 102 mg/L considered as soft to moderately hard according to Kannan (1991). The investigated sulphate values ranged from 3.914 mg/L to 8.328 mg/L, which was in acceptable level for fish culture (28). The nitrate values in our study ranged between 1.030 to 2.7260 mg/L. Singh and Gupta (30) reported the favorable range of nitrate in between 0.1mg/L to 4.00 mg/L. The nitrate values in the pond waters were within the acceptable level of aquaculture. However, this range may exceed and can cause eutrophication through the effect of other factors . The range of the salinity were found between 0.2 to 0.5 % in five samples. The chloride content values ranged from 21.3 to 23.1 mg/L which is similar to the findings of Anny et al. (25).

The water quality index (WQI) obtained from sample 1, sample 2, sample 3, sample 4 and sample 5 were found 84.93, 74.08, 57.5, 84.07 and 67.92 respectively in which sample 1 and sample 4 indicated very poor quality of water and sample 2, sample 3 and sample 5 indicated poor quality of water. All the obtained values of WQI depicted that aquaculture could not be carried out in such poor quality of water bodies of the ponds in AERE region.

Microbiological analysis of the water collected from the different fish ponds revealed a high microbial load and varied within the ponds. The coliform and fecal coliform growth were also observed in the study. The highest load of total viable bacteria (2.5×10^7 CFU/ml) was found in sample 1. This high bacterial load of water indicated that a huge number of bacteria were present in water and deteriorated the water quality in a great extent. The total coliform count observed throughout the study period were always much higher than the standard values of EQSB (Environmental Quality Standard for Bangladesh), Department of Environment, Government of the People's Republic of Bangladesh (1991). The values were found high due to water temperature which was optimum for bacterial growth and also due to the organic matter load found within pond water resulting from the diet used in feeding the fish. The persistence of pathogens in the water environment also is considered as one of the crucial factors for infection transmission in terms of acute outbreaks of disease. Thus, the ponds water can become an ideal culture medium for the proliferation of bacterial pathogens causing bacterial infection in fish and an important cause of food poisoning (31). The microorganisms isolated from the ponds were *E. coli, Salmonella typhi, Staphylococcus aureus, Klebsiella pneumoniae* which may be pathogenic to various aquatic life and may show a threat to the health of the fishes, aquatic systems and to the consumers.

5. Conclusion

Based on the results of physicochemical, bacteriological analysis and calculated values of water quality index (WQI) of the ponds in Atomic Energy Research Establishment (AERE) area, it can be concluded that the water bodies were highly contaminated by bacteria and were found not fit for aquaculture. The WQI values signified the poor quality of the pond waters. Among the physicochemical parameters, the DO values were found below the permissible limit of pond water which showed unsuitability for aquaculture. The presence of coliforms and fecal coliforms indicated fecal contamination. Thus, various mitigation procedures need to be adopted for protecting ponds and other water bodies associated with aquaculture from pollution to reduce the health hazards and to meet the protein requirements of our ever increasing population as well as to maintain the contribution of the aquaculture in the economic growth of our country.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest among the authors.

References

[1] Ghose B. Fisheries and aquaculture in Bangladesh: Challenges and opportunities. Ann Aquac Res. 2014; 1(1): 1–5.

[2] Shamsuzzaman MM, Islam MM, Tania NJ, Al-Mamun MA, Barman PP, Xu X. Fisheries resources of Bangladesh: Present status and future direction. Aquac Fish. 2017; 2(4): 145–56.

[3] Fisheries FAO. Aquaculture department. 2013. Glob Aquac Prod Stat year. 2011.

[4] Majumdar BC, Shaha DC, Rasul MG, Khan M. Fish Production in Floodplain of Bangladesh: A Review. Int J Nat Sci. 2016; 6(2).

[5] DoF. Fishery statistical yearbook of Bangladesh. Fisheries resources survey system. Department of Fisheries, Ministry of Fisheries and Livestock Dhaka, Bangladesh. 2001.

[6] Ali MM, Hossain MB, Minar MH, Rahman S, Islam MS. Socio-economic aspects of the fishermen of Lohalia River, Bangladesh. Middle-East J Sci Res. 2014; 19(2): 191–5.

[7] Mahmud S, Ali ML, Ali MM. Present scenario on livelihood status of the fishermen in the paira river, southern Bangladesh: constraints and recommendation. Int J Fish Aquat Stud. 2015; 2(4): 23–30.

[8] Torimiro N, Bebe PT, Ogundipe FE, Esan DM, Aduwo AI. The bacteriology and physicochemical analysis of fresh water fish ponds. Int Res J Microbiol. 2014; 5(3): 28–32.

[9] Sasson A. Feeding tomorrow's world. 1990.

[10] Federation WE, Association APH. Standard methods for the examination of water and wastewater. Am Public Heal Assoc Washington, DC, USA. 2005.

[11] Miller WW, Joung HM, Mahannah CN, Garrett JR. Identification of water quality differences in Nevada through index application. Wiley Online Library. 1986.

[12] Liou S-M, Lo S-L, Wang S-H. A generalized water quality index for Taiwan. Environ Monit Assess. 2004; 96(1): 35–52.

[13] Nasiri F, Maqsood I, Huang G, Fuller N. Water quality index: A fuzzy river-pollution decision support expert system. J Water Resour Plan Manag. 2007; 133(2): 95–105.

[14] Yogendra K, Puttaiah ET. Determination of water quality index and suitability of an urban waterbody in Shimoga Town, Karnataka. In: Proceedings of Taal 2007: The 12th world lake conference. 2008; 346.

[15] Taylor RH, Allen MJ, Geldreich EE. Standard plate count: a comparison of pour plate and spread plate methods. Journal-American Water Work Assoc. 1983; 75(1): 35–7.

[16] Holt JG, Krieg NR, Sneath PHA. Bergey's manual of determinative bacterology. 2013.

[17] Delincé G. The ecology of the fish pond ecosystem: with special reference to Africa. Springer Science & Business Media. 2013; 72.

[18] Boyd CE. Water quality in warmwater fish ponds: Auburn. Alabama, Auburn Univ Agric Exp Stn. 1979.

[19] Jamabo NA. Ecology of Tympanotonus fuscatus (Linnaeus, 1758) in the mangrove swamps of the upper Bonny River, Niger Delta, Nigeria. Ph. D. Thesis, Rivers State University of Science and Technology, Port. 2008.

[20] Ezekiel EN, Hart AI and Abowei JFN. The physical and chemical condition of Sombreiro river, Niger Delta, Nigeria. Research Journal of Environmental and Earth Sciences. 2011; 3(4):327-340.

[21] Chatterjee PR, Raziuddin M. Studies on the water quality of a water body at Asansol town, West Bengal. Nature, Environ Pollut Technol. 2007; 6(2): 289–92.

[22] Leclerc H, Schwartzbrod L, Dei-Cas E. Microbial agents associated with waterborne diseases. Crit Rev Microbiol. 2002; 28(4): 371–409.

[23] (WHO) WHO. Community water supply and sanitation: Needs, challenges and health objectives 48th World Health Assembly. A48/INEDOC/2, April. 1995; 28.

[24] Meade JW. Aquaculture management. Springer Science & Business Media. 2009;5(6):34-37

[25] Anny F, Kabir M, Bodrud-Doza M. Assessment of surface water pollution in urban and industrial areas of Savar Upazila, Bangladesh. Pollution. 2017; 3(2): 243–59.

[26] DoF. Department of Fisheries, Fishery Statistical Yearbook of Bangladesh 2008-2009. Fisheries Resources Survey System, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. 2010,26(1).

[27] Solis NB. Biology and ecology. In Biology and culture of Penaeus monodon. Aquaculture Department, Southeast Asian Fisheries Development Center. 1988; 67(8):3-36.

[28] Ekubo AT, Abowei JFN. Review of some water quality management principles in culture fisheries. Res J Appl Sci Eng Technol. 2011; 3(12): 1342–57.

[29] Bhatnagar A. and Devi P. Water quality guidelines for the management of pond fish culture. International Journal of Environmental Sciences. 2013; 3(6).

[30] Singh MR, Gupta A. and Beeteswari KH. Physico-chemical properties of water samples from Manipur river system, India. Journal of Applied Sciences and Environmental Management. 2010;14(4).

[31] Eze VC, Ogbaran IO. Microbiological and physicochemical characteristics of fish pond water in Ughelli, Delta State, Nigeria. Int J Curr Res. 2010; 8: 82–7.