J. Agrofor. Environ. 5 (2): 121-123, 2011 ISSN 1995-6983

Feasibility of underground water for fish culture in the southern region of Bangladesh: a case study from Laxmipur and Chittagong area

Md. Shakhawate Hossain, [1]Riaz Hossain Khan and [2]Ayesha Akter

Department of Fisheries Biology and Aquatic Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh; [1]Deapartment of Environmental Science, [2]Deapartment of Emergency Management, Patuakhali Science and Technology University, Bangladesh, E-mail: shselim09@gmail.com; +8801716232126

Abstract: Water quality and quantity vary from place to place, and are affected by ecological factors such as soil and air quality. In these study; experiment were conducted to measure and compare the water quality parameter of underground water in the southern districts of Bangladesh. Water quality parameters such as temperature (^oC), pH and dissolved oxygen (mgL^{-1}), alkalinity, hardness, different ion such as sodium, chlorine, nitrate-nitrite and iron were measured and compared with required parameter for fish culture. In this experiment water quality parameters of underground water were found more likely similar or in acceptable range for fish culture except DO, salinity and concentration of iron in few sampling point locations. Salinity in groundwater were observed slightly higher than surface water bodies. Problem of DO and iron can be mitigated by the use of aerator. Aeration helps to increase oxygen content of water as well as precipitate the iron. On a whole, groundwater is considered more desirable for aquaculture because it has more consistent water quality than surface water, and is less likely to be contaminated by pathogens.

Key words: Feasibility, underground water, fish culture, Bangladesh, Laxmipur, Chittagong.

Introduction

Fisheries sector is playing a very vital role regarding employment generation, animal protein supply, foreign currency earning as well as poverty alleviation in Bangladesh. Fish production in ponds, lakes, borrowpits, floodplains, oxbow lakes and semi-closed water bodies is increasing day-by-day through modern technology. Aquaculture in Bangladesh has been developed as elsewhere in this South Asian region through the culture of large carps of both native (e.g. rui, catla and mrigal) and exotic (e.g. silver, grass and common carp) origin. Cultures of fish mainly depend on natural water (surface water, rainfall) as well as underground water from shallow and deep tube well. Growth and survival, which together determine the ultimate yield, are influenced by a number of Physical & Chemical parameters and managerial practices. Physical & Chemical parameters for aquaculturists refer to the quality of water that enables successful propagation of the desired organisms. The required water quality is determined by the specific organisms to be cultured and has many components that are interwoven. Aquaculture ponds are a living dynamic systems they exhibits continuous and constant fluctuations. The pond undergoes a vast collection of both chemical reactions and physical changes. These changes occur due to household runoff, environmental temperature, soil-water & air-water interaction etc. And these fluctuations more in surface water than underground water. Surface water chemistry does not generate any great problem in fish culture except southern region of Bangladesh. Most of the cultured fish species of Bangladesh are freshwater inhabitant. They can’t survive or growth hampered in saline water.

In the southern region of Bangladesh culture of freshwater fish species hampered due to saline water intrusion from shrimp farm as well as different natural and manmade causes. There are few techniques available to mitigate the problem, use of underground water may be one of the most important and effective means. Therefore to solve the existing problem, an attempt has been taken to measure the suitability of underground water for fish culture. Good production from aquaculture ponds can be achieved when the pond and surroundings make chemical and physical exchanges at a steady state.

Materials and Methods

Twenty-eight numbers of groundwater samples were collected in February 2010 from both shallow and deep tubewells at the studied area. Two 250ml PVC bottles were used for sampling. During sampling, 0.45 μm membrane filters was used to filter groundwater samples in order to remove colloidal material and other unwanted particles from the water samples. One bottle of sample was acidified to measure the cations especially to avoid the precipitation of dissolved heavy metals using concentrated HCL by lowering the pH value to less than 3 and another unacidified sample was used to measure the anions. A GARMIN 12 channel GPS was used to record the geographic location of the sampling points. Electrical Conductance (EC), Total Dissolved Solid (TDS), pH, Temperature and Dissolved Oxygen were recorded for each sample on the spot using portable EC-meter, pH-meter and DO meter respectively. The concentrations of Na^+ and K^+ ions of the samples were determined by using Jenway PFP7 Flame Photometer. Ca^{2+}, Mg^{2+}, Fe^{2+} and Mn^{2+} concentrations were determined by using Spectrosonic GENESYS5 spectrophotometer. HCO_3 and Cl^- concentrations were determined by titration method.

Results and Discussion

All biological and chemical processes in an aquaculture operation are influenced by temperature. Fish adjust their body temperature and metabolic rate by moving into cooler or warmer water. At temperatures above or below optimum, fish growth is reduced. Mortalities may occur at extreme temperatures. Optimum temperature for warm water fish growth is 25-30^{0}C. In this study underground water temperature ranges between 23.29 – 28.43^{0}C in Laxmipur and Chittagong which can be considered suitable for their optimum production and survival.

Dissolved Oxygen: Dissolved oxygen (DO) level of Deep tube well was not measured but in shallow tubewell were found 0.35 mg/l and 2.21 mg/l in Laxmipur and Chittagong respectively. The minimum dissolved oxygen (DO) level that fish can safely tolerate depends upon temperature and to a certain extent the species. Acceptable range of dissolved oxygen concentration in water for fish culture is 5- 15 mg/l (Boyd 1998, Table 1).

Table 1. Acceptable Concentration Ranges for Dissolve Inorganic Substances in Aquaculture Pond Waters Boyd (1990 & 1998)

Element	Form in water	Desired concentration
Oxygen	Molecular Oxygen (O2)	5 – 15 mg/l
Hydrogen	H+[-log(H+) = pH]	PH 7 – 9
Nitrogen	Molecular Nitrogen (N2) Ammonium (NH4 +) Ammonia (NH3) Nitrate (NO3 -) Nitrite (NO2 -)	Saturation or less 0.2 – 2 mg/l < 0.1 mg/l 0.2 – 10 mg/l < 0.3 mg/l
Sulfur	Hydrogen Sulfide (H2S) - rotten egg gas Sulfate (SO4 -)	Not detectable 5 – 100mg/l
Carbon	Carbon Dioxide (CO2)	1 – 10 mg/l
Calcium	Calcium Ion (Ca2+)	5 – 100 mg/l Can be higher in crustacean ponds
Magnesium	Magnesium ion (Mg2+)	5 – 100 mg/l
Sodium	Sodium ion (Na+)	2 – 100 mg/l
Potassium	Potassium ion (K+)	1 – 10 mg/l
Bicarbonate	Bicarbonate ion (HCO3 -)	50 – 300 mg/l
Carbonate	Carbonate ion (CO3 2-)	0 – 20 mg/l
Chloride	Chloride ion (Cl-)	1 – 100 mg/l
Phosphorus	Phosphate ion (HPO4 2-, H2PO4 -)	0.005 – 0.2 mg/l
Iron	Ferrous iron (Fe2+) Ferric iron (Fe3+) Total iron	0 mg/l Trace 0.05 – 0.5 mg/l
Manganese	Manganese ion (Mn2+) Manganese dioxide (MnO2) Total manganese	0 mg/l Trace 0.05 – 0.2 mg/l

As a rule of thumb, DO should be maintained above 3.0 ppm (parts per million; frequently used interchangeably with milligrams per liter, mg/L) and 5.0 ppm for warm and coldwater fish, respectively. Prolonged exposure to low, nonlethal levels of DO constitutes a chronic stress and will cause fish to stop feeding, reduce their ability to convert ingested food into fish flesh, and make them more susceptible to disease. Intensive fish production in ponds, cages, flow-through, and recirculating systems requires aeration or oxygenation to maintain DO at safe levels (Joseph K. Buttner *et. al.*, 1993).

pH: The concentration of bases and acids in the water determines its pH. A low pH is acidic and a high pH is basic; a pH of 7 is neutral. Fish survive and grow best in waters with a pH between 6- 9. If pH readings are outside this range, fish growth is reduced. At values below 4.5 or above 10, mortalities occur. pH of underground water found 6.91, 6.58, in shallow tube well of Laxmipur & Chittagong and 6.93, 7.10 deep tube well of Laxmipur & Chittagong respectively.

Alkalinity: The buffering capacity of culture water, expressed as ppm calcium carbonate, is its alkalinity. Alkalinity is a measurement of carbonate and bicarbonate ions (ions are atoms or groups of atoms with a negative or positive charge) dissolved in the water. Bicarbonate ions (HCO_3^-) concentration of shallow and deep tube well of Laxmipur and Chittagong were found respectively 224.35, 184.46, 165.05, and 114.02 ppm. In a pond with higher alkalinity, the pH shift is reduced. For instance, the daily shift in a well buffered pond might be from a pH of seven in the morning to eight by late afternoon. A suitable range of alkalinity is 20 to 300 ppm. Alkalinity in excess of 300 ppm does not adversely affect fish, but it does interfere with action of certain commonly used chemicals (e.g., copper sulfate). Alkalinity remains relatively constant in ponds, but decreases steadily in nonsupplemented, recirculating systems. Alkalinity can be increased by adding agricultural limestone to ponds or sodium bicarbonate to recirculating systems (Joseph K. Buttner *et. al.*, 1993).

Hardness: Calcium and magnesium ions comprise hardness. Test procedures usually determine both ions as "total hardness," expressed as ppm calcium carbonate. In most waters the concentrations of alkalinity and hardness are similar, but they can differ vastly as alkalinity measures negative ions (carbonate, bicabonate) and hardness measures positive ions (calcium, magnesium). Hardness is important, especially in the culture of several commercial species such as striped bass and catfish. If hardness is deficient, these species do not grow well. Hardness should be above 50 ppm; low hardness can be adjusted by the addition of lime or calcium chloride. In our study Ca2+ ion concentration were observed greater than 33 ppm and Mg2+ ion concentration between 6 and 35 ppm (Table 2).

Iron: Many groundwaters contain elevated levels of dissolved iron (Joseph K. Buttner *et. al.*, 1993). In this study the same result were obtained with higher concentration of iron in most of the water samples which ranges between 0.71 and 5.07 (Table 2). When exposed to the air, this iron interacts with oxygen, becomes insoluble, and forms a red deposit. Small clumps of iron are produced that can settle on fish gills, causing irritation and stress. Problems can be avoided if the iron-bearing water is exposed to air and the resultant clumps of iron removed by settling or filtration before the water enters the culture system.

Table 2. Water quality parameters of underground water in Lakhipur and Chittagong Districts (mean values)

Parameters	Deep Tubewells water		ShallowTubewells water	
	Laxmipur	Chittagong	Laxmipur	Chittagong
pH	6.91	6.58	6.93	7.10
Temp	23.29	28.43	26.70	28.43
DO	A	A	0.35	2.21
Na^+(mg/L)	120.67	146.62	110.87	105.32
K^+ (mg/L)	6.34	5.27	6.53	9.57
Ca^{2+} (mg/L)	45.35	33.88	68.58	46.97
Mg^{2+} (mg/L)	15.52	6.96	35.52	19.25
Cl^- (mg/L)	192.55	244.72	229.72	207.73
HCO_3^- (mg/L)	184.46	114.02	224.35	165.05
NO_3^- (mg/L)	0.08	0.04	0.01	0.01
SO_4^{2-} (mg/L)	0.30	0.35	2.05	7.67
$PO4_3^-$ (mg/L)	0.07	0.14	0.04	0.07
Mn (mg/L)	0.11	0.49	0.95	0.35
Fe (mg/L)	0.71	4.07	5.07	2.35
As (mg/L)	0.035	0.032	0.078	0.008

Chlorine and Sodium: To control bacteria, municipal water supplies are typically treated with chlorine at 1.0 ppm. If municipal waters are used to culture fish, residual chlorine must be removed by aeration, with chemicals such as sodium thiosulfate, or filtration through activated charcoal. Chlorine levels as low as 0.02 ppm can stress fish. Underground water of study area of southern region of Bangladesh contains high level of chlorine (Cl-) which ranges between 192.55 and 244.72. At the same time Na+ ion level also elevated compare to normal surface water. These are might be due to saline water seepage or intrusion from sea.

Other Ion: There are other ions like sulfate (SO4-), nitrate (NO3-), phosphate (PO4-), arsenic (As) etc which are also very important for fish culture. In our present study we found sulfate, nitrate, phosphate and arsenic concentration in underground water of Chittagong and Laxmipur districts respectively as 2.59, 0.03, 0.08 and 0.04 ml/l; which is in between the normal range for fish culture.

The major water quality factors that are important in freshwater aquaculture systems are described in this publication. Water quality determines not only how well fish will grow in an aquaculture operation, but whether or not they survive. Some water quality factors are more likely to be involved with fish losses such as dissolved oxygen, temperature, and ammonia. Others, such as pH, alkalinity, hardness and clarity affect fish, but usually are not directly toxic. Each water quality factor interacts with and influences other parameters, sometimes in complex ways. All these factors of underground water are in likely acceptable range of aquaculture pond except dissolved oxygen (DO). This may be due to limited interaction of water and air. If air-water interaction increase dissolved oxygen concentrations will increase. Finally we can say underground water can be used in aquaculture system for fish culture.

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