Trakia Journal of Sciences, No 1, pp 82-88, 2014

Available online at:
http://www.uni-sz.bg

ISSN 1313-7050 (print)
ISSN 1313-3551 (online)

Original Contribution

CHEMICAL AND BIOLOGICAL PARAMETERS OF POTABLE WATER IN KOGI STATE METROPOLIS OF NIGERIA – IMPLICATIONS FOR FISH POND CULTURE

V. T. Okomoda*, S. G. Solomon, G. A. Ataguba

Department of Fisheries and Aquaculture, University of Agriculture Makurdi, Nigeria

ABSTRACT
Potable water is the cheapest source of water for aquaculture in areas not close to surface water and with little potential for ground water usage; hence this study attempts to evaluate the physicochemical and microbial quality of potable water with a view of establishing possible implication on fish-culture. Data gathered between 2009 and 2012 showed that most physicochemical parameters where within acceptable limits of WHO for drinking water; value of most parameters were also within ranges recommended for intensive fish-culture, however Phosphorus, Nitrate as well as Manganese and Phenolphthalein Alkalinity were not detected. Although Total viable bacteria count was higher in 2012 compared to other years, and was attributed to the flooding of river Niger and Benue in the same year; microbial analysis of potable water in the study area reveals no tendency of pathogenic threat if used for fish farming (but water collected in the 2012 could post health hazard to human health).Therefore if potable water is to be used as a source of water for fish culture, fertilization is however recommended so as to supply Phosphorus and Nitrate which are integral part of primary productivity.

Key words: Physicochemical parameters, Acceptable limits, Fish production Total viable bacterial.

INTRODUCTION

Water is the most vital requirement for a successful aquacultural venture, thus, its quality is very important. Evaluations of water quality parameters are necessary to enhance the performance of an assessment operation and develop better water resources management and plan (1). Water quality directly affects virtually all water uses. Fish survival, diversity and growth; recreational activities such as swimming and boating, municipal, industrial, and private water supplies, agricultural uses such as irrigation and livestock watering, waste disposal, and general aesthetics-all are affected by the physical, chemical, biological, and microbiological conditions that exist in watercourses and in subsurface aquifers (1).

Rapid and unplanned urbanization, commercial development along with population pressure have made an environmentally polluted city in the world (2, 3). Consequently, complex mixture of hazardous chemicals, both organic and inorganic are released into water resulting in different chemical and biochemical interactions in the river system and thus deteriorate the water quality (4). In tropical Africa, potable water is fast becoming the most cheapest and available water for aquaculture especially in areas not close to surface water or areas with little potential for ground water usage (5) however, there is little or no information on its water quality in relation to aquacultural practices as the level of most physicochemical parameters are not well documented despite they have great effect on fish production, reproduction and survival. Since the importance of water as a requirement for aquaculture is not only tied to its availability and quantity, but also to its quality as it supports the aquatic lives; it therefore important to examine the physicochemical as well as biological parameters of potable water

***Correspondence to:** *Okomoda V. T., Department of Fisheries and Aquaculture, University of Agriculture Makurdi, Nigeria, +2348033319959, okomodavictor@yahoo.com*

with a view of their underlining consequence on aquacultural activities hence the aim of this research. Information provided in this study will assist in better management of this water resource for aquaculture purpose.

MATERIALS AND METHODS

The present study was conducted from 2009 to 2012 in Kogi state Nigeria. It geographical coordinates are 8°06′N6°48′E8.1°N 6.8°E. Potable water sample were collected quarterly every year during the study period (2009-2012) in 50 litters containers from three local government areas namely Lokoja, Kabba, and Okene and analyzed for physicochemical parameters and biological water quality at Kofa services Jos according to APHA (6). Summary statistics of the Water qualities, Analysis of variance and mean separation using LSD and correlation matrix between these factors were determined using Gen stat® software discovery edition 3 (7).

RESULTS AND DISCUSSIONS

The qualities of water are generally explained by its physicochemical and biological properties. The amount of dissolved oxygen in water is very important for aquatic organisms. Dissolved oxygen affects the growth, survival, distribution, behavior and physiology of all aquatic organisms (8, 9). The values of dissolved oxygen (DO) range between 5.45 and 5.75 ppm **(Table 1)** and were statistically same for the years within which the study was conducted. The high value recorded during this study period is probably due to high pressure and agitation by pumps during purification process and distribution, higher DO values reported by Kolo, (10) were attributed to agitation and frequent wind current in water during the wet seasons. Oxygen is required for respiration of aquatic organism, the DO recommended for the survival of aquatic life in tropical water by Ayodele and Ajani (11) Olukunle (12) and Boyd (13) is between 3 and 5 ppm.

Table 1. *Physico-chemical water quality of potable*

Parameters	2009	2010	2011	2012	P value.
DO	5.55 $\pm$ 0.25	5.75 $\pm$ 0.755	5.60 $\pm$ 0.3	5.45 $\pm$ 0.05	0.966
T. Solid	0.095 $\pm$ 0.005^{c}	0.055 $\pm$ 0.005^{c}	0.47 $\pm$ 0.03^{a}	0.10 $\pm$ 0.002^{b}	0.01
pH	6.25 $\pm$ 0.25^{b}	7.4 $\pm$ 0.1^{a}	7.1 $\pm$ 0.1^{a}	7.25 $\pm$ 0.05^{a}	0.017
T. Alkalinity	62.5 $\pm$ 2.5^{c}	132.5 $\pm$ 7.5^{b}	210 $\pm$ 10^{a}	25.25 $\pm$ 1.15^{d}	0.01
P. Alkalinity	N.D	N.D	N.D	N.D	
T. Hardness	19.0 $\pm$ 1.0^{b}	85.0 $\pm$ 5.0^{a}	12.5 $\pm$ 2.5^{b}	17.8 $\pm$ 1.1^{b}	0.01
Na^{+}	5.7862 $\pm$ 0.02^{d}	9.067 $\pm$ 0.05^{c}	20.338 $\pm$ 0.382^{b}	27.52 $\pm$ 1.79^{a}	0.01
K^{+}	2.933 $\pm$ 0.05^{b}	3.139 $\pm$ 0.1^{a}	0.3664 $\pm$ 0.0005^{c}	0.428 $\pm$ 0.106^{c}	0.01
Mg^{2+}	4.4389 $\pm$ 0.06^{b}	10.95 $\pm$ 0.25^{a}	4.802 $\pm$ 0.062^{b}	2.30 $\pm$ 0.1^{c}	0.01
Mn	N.D	N.D	N.D	N.D	
Ca^{2+}	3.202 $\pm$ 0.004^{c}	16.79 $\pm$ 0.75^{a}	3.20 $\pm$ 0.003^{c}	6.30 $\pm$ 0.4^{b}	0.01
Fe^{+}	0.09 $\pm$ 0.01^{a}	0.00 $\pm$ 0.00^{c}	0.09 $\pm$ 0.01^{a}	0.05$\pm$ 0.02^{b}	0.01
P^{+}	N.D	N.D	N.D	N.D	
Cl^{-}	5.434 $\pm$0.033^{bc}	14.0 $\pm$ 2.00^{b}	34.5 $\pm$ 4.5^{a}	2.7 $\pm$ 0.1^{c}	0.003
SO_4^{2-}	8.773 $\pm$ 0.074^{b}	3.576 $\pm$ 0.121^{c}	1.625 $\pm$ 0.05^{d}	12.7 $\pm$ 0.2^{a}	0.01
NO_3^{-}	N.D	N.D	N.D	N.D	

Means in the same Roll with different superscripts differ significantly (P<0.05)
N.D means Not detected.

The pH range observed for the present study were between 6.25 and 7.4 **(Table 1)** and were positively correlated (P<0.05) with years **(Table 2)** i.e. as the years increased so the pH. The observed values are in agreement with Boyd (13). The pH range for existence of most biological life is quite narrow and critical; Ayodele and Ajani (11) recommended a pH range of 6.5 and 9 for best fish production while Olukunle, (12) and Pescord (14) recommended a range of 6.5 and 8.5. The acceptable pH range for drinking water is between 6.0 and 9.0 as recommended by FEPA (15). Abowei (16) noted that pH higher than 7 but lower than 8.5 is ideal for biological productivity while pH lower than 4 is detrimental to aquatic life. Growth of most fish species is affected at pH below 6.0 or above 9.0 (17). Lower pH values is usually attributed to the decay process of allocthonous organic matter hence the purification process of the potable water may be the cause of higher pH value recorded in the present study.

The alkalinity of a water body refers to the quantity and kinds of dissolved ions (anions), which collectively shift the pH to the alkalinity side of the scale. There are three types of alkalinity namely: carbonate alkalinity (caused by carbonates and bicarbonates), phenolphthalein alkalinity (due to hydroxyl ions) and total alkalinity (the sum total of the two). The absents of phenolphthalein alkalinity recorded along the years **(Table 1)** of the present study shows that alkalinity were only caused by carbonates and bicarbonates ($CaCO_3$). Boyd (18) observed that waters with total alkalinities between 20 and 50 mg/L permit plankton production for fish culture and only water samples collected in 2012 falls within this range **(Table 1)**. Waters with high alkalinity are undesirable because of the associated excessive hardness or high concentration of sodium salts. Alkalinity in the range of 30 to 500 mg/L is generally acceptable to fish and shrimp production (19). Alkalinity in natural surface waters rarely exceeds 500mg/l and it is desirable that there should be no sudden variations in the alkalinity of waters so that productivity is not affected (20). However with purification as in the case of potable water alkalinity will reduce.

Phosphorus and Nitrate (NO_3^-) are very important component in water for the culture of aquatic organisms however both elemental components were not detected during the study time frame **(Table 1)**. Phosphorus gets into the water through various sources including leached or weathered soils from igneous rocks and domestic sewage containing human excrement. Other sources are phosphates from detergents in industrial effluents and run offs from fertilized farm lands. Phosphorus is very important for plant growth including algal growth in water (21). Phosphates are absorbed by aquatic plants and algae and constitute an integral part of their body component. The total concentration of phosphorus in uncontaminated waters is reported to be about 0.01 mg/L (16). On the other hand, Nitrate (NO_3^-) is the major form of nitrogen found in natural waters. Other form of nitrogen present in natural waters includes molecular nitrogen (N_2) in solution; ammonia as NH_3; ammonium and ammonia hydroxides (NH_4 and NH_4OH) and nitrate as NO_3. Davies *et al*. (22) reported that surface waters rarely contain as much as 5 mg/L and often less than 1 mg/L of nitrate. The sources of nitrates in water include human and animal wastes; weathering of igneous and volcanic rocks; oxidation of vegetable and animal debris. Other sources include excrement and the nitrification (conversion of ammonia or nitrite to nitrate) process in the nitrogen cycle in water. Nitrates are important for growth of plants and aquatic organisms such as algae. Weidner and Keifer (23) observed that nitrates limit phytoplankton growth in water. Small concentrations of nitrates are sufficient to stimulate phytoplankton growth (24). Hepher and Pruginin (25) reported that nitrate levels higher than 1.4 mg/L did not have any effects in fish ponds. Wickins (26) noted that below 100 mg/NO_3^-, no toxic effects to fish were observed. Hence if this cheap source of water is to be harnessed for fish pond culture, fertilization of the water is very necessary to encourage the growth of plankton which is an integral part of fish culture so as to make both phosphorus and inorganic nitrogen play an important role in the eutrophication process (27) available.

Hardness of water is due to the presence of chloride, sulfate, carbonate, bicarbonate etc. salt of Ca^{2+} and Mg^{2+} hence hardness was positively correlated with these two elements **(Table 2)**. Though, WHO (28, 29) reported that minor contributors to hardness of water include ions of aluminum, barium, manganese, iron, zinc etc. the present study with an undetected manganese and a negatively correlated relationship between Hardness and iron **(Table 2)** suggest that this metal may not have contributed significantly to the water hardness level. The range of total hardness in drinking water samples reported by Koul et al (30) were between 23 mg/L and 29 mg/L and were comparable with the findings of the present study. However, all the water samples from all years show that the range was within permissible WHO (31) and BIS (32) limits of 300 mg/L for drinking water. Apparently, effect of water hardness on aquatic life varies according to life stage, species and water quality (33). Spade & Bristow, (34) reported that low water hardness heighten increase in egg diameter because the swelling process of flaccid newly shed eggs is higher when they first contact water and absorb water. However, neither the hatching rate nor the growth of Mozambique tilapia larvae were affected by exposure to waters with 2-3 or 88-96 mg L–1 $CaCO_3$ (35).

Table 2. *Correlation Matrix between the physicochemical water qualities of potable water*

Cl^-	-0.14											
DO	0.12	0.10										
Fe^{2+}	-0.95**	0.24	-0.21									
K^+	0.52	-0.35	0.17	-0.42								
Mg^{2+}	0.86**	0.19	0.20	-0.74*	0.67							
Na^+	-0.27	0.11	-0.15	0.16	-0.93**	-0.59						
SO_4^{2-}	-0.24	-0.86**	-0.18	0.10	-0.12	-0.62	0.31					
T. Alkalinity	0.05	0.94**	0.22	0.05	-0.14	0.41	-0.09	-0.96**				
T. Hardness	0.98**	-0.10	0.14	-0.89**	0.65	0.94**	-0.46	-0.34	0.13			
T. Solid	-0.52	0.89	-0.05	0.56	-0.64*	-0.25	0.36	-0.59	0.76*	-0.50		
pH	0.58	0.23	0.13	-0.59	-0.32	0.34	0.50	-0.22	0.26	0.45	0.07	
Years	-0.09	0.11	-0.11	-0.04	-0.87**	-0.43	0.98**	0.25	-0.05	-0.28	0.29	0.64*
	Ca^{2+}	**Cl^-**	**DO**	**Fe^{2+}**	**K^+**	**Mg^{2+}**	**Na^+**	**SO_4^{2-}**	**T. Alkalinity**	**T. Hardness**	**T. Solid**	**pH**

Value with * Differs significantly at $P<0.05$, while those with ** differ significantly at $P<0.01$

Ca^{2+} and Mg^{2+} are important for ionic regulation of freshwater fish because both ions influence the permeability of biological membranes, preventing diffusive flow out of the tissues and high ionic loss to water (36). Calcium has an important role in the biological processes of fish. It is necessary for bone formation, blood clotting and other metabolic reactions. Freshwater fish take up Ca^{2+} predominantly through the gills, and even those fed a Ca^{2+} deficient diet grow normally if there is enough waterborne Ca^{2+} to be absorbed (37). However, in low Ca^{2+} water the relative contribution of calcium ions from food increases as a compensatory mechanism (38). The present study recorded Ca^{2+} range of 3-16 mg l^{-1} **(Table 1)** hence could support the average uptake of calcium for fish. Several studies have indicated that freshwater teleosts primarily depend on dietary rather than waterborne Mg^{2+}, with the gills being a secondary route for absorption (36) i.e. only if the water presents an adequate amount of Mg^{2+}, branchial uptake may be enough to compensate a low-Mg^{2+} diet in some species. High waterborne Mg^{2+} (up to 50 mmol) did not affect *Gasterosteus aculeatus*, Mozambique tilapia, *Oreochromis mossambicus*, and goldfish (36). Mg^{2+} level of potable water in the present study although lower than Ca^{2+} level will be enough to compensate the amount absolvable in the feed.

The total dissolved solids (TDS) of water refers to the inorganic salts and organic matter present in water which may be due to the presence of sodium, potassium, calcium, magnesium, carbonates, hydrogen carbonate and ions of chloride, sulfate and nitrate (31). It is also an important chemical parameter of water (39). Total suspended solids in all the years of the present study (as shown in **Table 1)** were far lower than 30 ppm recommended by FEPA (1991), Boyd and Licktkippler (40). This will affect the transparency and turbidity of the water and hence the light penetration. This will affect the life of the water plankton and hence the fish food in the presence of high nutrient will increase. Total Dissolved Solids content of the drinking water samples collected from various sites of Gurgoan as reported by Koul et al (30) showed a range between 92 mg/L to 160 mg/L which is higher compared to the present study, however the efficiency of purification may be the cause of difference in the present study. The water samples were at large below the 500 mg/L value given by WHO (31).

WHO (31) gave 0.2, 200 and 250mgl^{-1} as save level of Iron, sodium and chloride respectively for potable water, hence the water from the present study were within the save limit for human consumption. Surma River analysis during dry and monsoon periods by Alam, *et al.* (41) reported ranges between 0.28- 3.16 mgl^{-1} for iron and was higher compared to the result of the present study, however they are within the range recommended for cold and warm blooded fish reared in intensive culture by Wedemeyer and Goodyear (42), Post (43) and Klontz (44).

Koul et al.,'s (30) study on the Bacteriological analysis of potable water sample from Gurgoan reveals no fecal bacteria, however total coliform bacteria range of 2–20/100 mL was recorded, while contamination of total coliform bacteria was found to be 30.7 percent of the tap water samples. The values recorded for 2010 and 2011 **(Figure 1)** compared to that of the report of Koul et al., (30) and may be attributed to the efficiency of purification methods used in the different study areas. However flooding of river Niger and Benue is the cause of higher microbial loading recorded in samples collected in 2012. The result of the present study were however lower than the range reported in the finding of Kavka & Poetsch (45) for river. However, the present assessment of bacteriological analysis is within limits for rearing tropical fishes.

In conclusion, physico-chemical parameter of potable water sample analyzed in the present study are within recommended range for fish culture, however the complete absence or non detectable value of Phosphorus and Nitrate which is important for primary productivity pose a major challenge, therefore fertilization is recommended so as to supply these important micronutrients, more so, based on the flooding recorded in 2012, the efficiency of purification of water should be improved as microbiological contamination observed during this period could pose threat to human consumption.

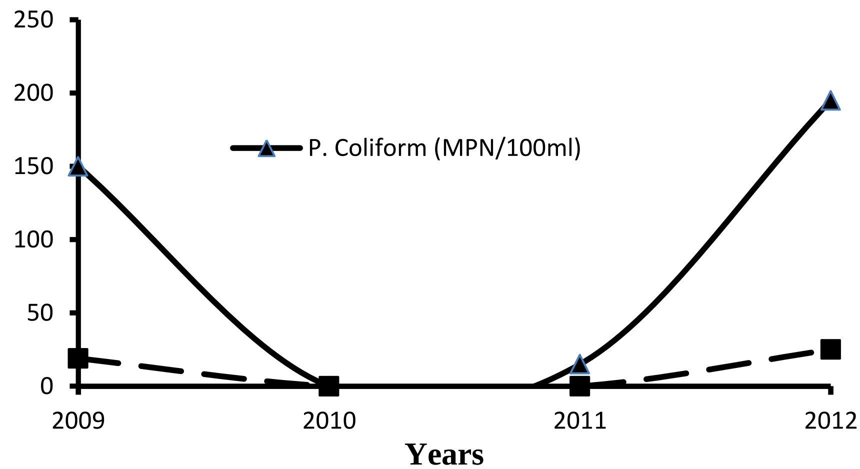

Figure 1. Graph showing microbiological water quality per year of the study.

REFERENCES

1. Ali, Ahmed E, Othman A. K. and Othman J..Prediction of Johor River Water Quality Parameters Using Artificial Neural Networks. *European Journal of Scientific Research* Vol.28 No.3, pp.422-435, 2009.
2. Haigh M. J.. Sustainable Management of headwater Resources: The Nairobi „Headwater" Declaration (2002) and Beyond, *Asian J. Water, Environ. Pollut*., 1(1-2): 17-28, 2004.
3. Karn S. K. and Harada H.. Surface water pollution in three Urban Territories of Nepal, *India, and Bangladesh. Environ. Manage.*, 28(4): 438-496, 2001.
4. Rahman A. K. M. L., Islam M., Hossain M. Z. and Ahsan M. A..Study of the seasonal variations in Turag river water quality parameters. *African Journal of Pure and Applied Chemistry* Vol. 6(10), pp. 144-148, 2012.
5. Jonnalagadda S. B. and Mhere G., 'Water quality of the Odzi River in the eastern highlands of Zimbabwe', *Water Res.* 35(10), 2371–2376, 2001.
6. American Public Health Association (APHA). Standard Methods for the

Examination of Water and Waste Water. 20th Edn., Washington DC., pp: 1161, 1998

7. VSNi. GenStat Discovery Edition 3. VSN International Ltd #5 The Waterhouse, Waterhouse Street, HemelHempstead, HP1 1ES UK. Retrieved September 14, 2008, fromhttp://www.vsni.co.uk/2008/home-pages/softwarefor- developing-countries, 2008.
8. Ajibade, W. A., Ayodele, I. A. and Agbede, S. A.. Water quality parameters in the major rivers of KainjiLake National Park, Nigeria. *African Journal of Environmental Science and Technology* Vol. 2 (7), pp. 185-196,2008.
9. Solis N. B.,. Biology and Ecology of *Penaeus monodon.* In: Biology and Culture of *Penaeus monodon* SEAFDEC. Aquaculture Department, Tigbauan Iloilo, Philippines, pp: 3-36, 1988.
10. Kolo A. I.. The Assessment of Physio-Chemical Parameters of Shiroro Lake and Its Major tributries. Proceedings of 1996 FISON Conference. pp 260-268, 1996.
11. Ayodele I. A.and Ajani E. K.. Essential of Fish Farming. Pub. Odua Printing Co. Ltd. Ibadan p. 39, 1999.
12. Olukunle O.. Homestead Pond Management. Published by John Archers (Publishers) Ltd. Ibadan, p.34, 2000.
13. Boyd C. E.. Water Quality In Warm – Water Fish Pond. Published by Auburn University p.359,1981.
14. Pescod M. B.. Surface Water Quality Criteria for Developing Countries in Water, Wastes and Health in Hot Climates Feachem. R. McGorng M. and Maro. D. (eds) (London: John Wiley), pp. 52-77, 1977.
15. FEPA Guidelines and Standards for Environmental Pollution Control in Nigeria pp.15-33, 1991.
16. Abowei, J. F. N.. Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. *Adv. J. Food Sci. Technol*., 2(1): 16-21, 2010.
17. Parra J. E. G. and Baldisserotto B.. Effect of water pH and hardness on survival and growth of freshwater teleosts. In: Baldisserotto, B.; Mancera, J.M.; Kapoor, B.G. (Eds.) Fish osmoregulation. New Hampshire: Science Publishers. p.135-150, 2007.
18. Boyd C. E.. Water Management for Pond Fish Culture. Elsevier Scientific Publications, Amsterdam Development on Aquaculture and Fisheries Science, 9: pp: 231, 1982.
19. McNeely R. N., Neimanis V. P. and Dweyer L.. Water quality source book: A guide to water quality parameters. Inland waters Directorate, Water quality branch Ottawa, Canada, pp: 88,1979.
20. Manaham S. E.. Environmental Chemistry. 6th Edn., Lewis Publishers. Ann Abor London, Tokyo, pp: 812, 1994.
21. Abowei, J. F. N., Davies O. A. and Eli A.. Physicochemistry, morphology and abundance of fin fish of Nkoro River, Niger Delta, *Nigeria. Int. J. Pharm. Biosci*., 6(2) pp: 1-11, 2010.
22. Davies O. A., Ugwumba A. A. A. and Abolude D. S.. Phytplankton of the lower reaches of Okpoka creek, Port Harcourt, Nigeria. *J. Fish. Int.*, 3(3): 70-77,2008.
23. Weidner M. and Keifer H.. Nitrate reduction in marine brown algae. Giffordia mitchellae (Harv.) Ham. Z. ptlanzenphysiol., 104: 341-351, 1981.
24. Kutty M. N.. Site selection for aquaculture: chemical features of water. Working Paper African Regional Aquaculture Centre, Port Harcourt. ARAC/87/WP/2(9). pp: 53, 1987
25. Hepher B. and Pruginin Y.. Commercial Fish Farming With Special Reference to Fish Culture in Israel. John W iley and Sons, New York, pp: 261, 1981.
26. Wickins J. F.. Water Quality Requirements for Intensive Aquaculture. A Review. In: Tiews, K. (Ed.), Proceeding. World Symp. On aquaculture in Heated Effluents and Recirculation System, Stavager, 28-30 May, 1980, Vol: 1. Berlin, pp. 17-37. 1981.
27. Soulsby C., Langan S. J. and Neal C.. 'Environmental change, land use and water quality in Scotland: current issues and future prospects', *Sci. Total Environ.* 265, 387–394, 2001.
28. WHO (2006). Guidelines for Drinking – Water Quality. Vol 1. (Geneva: WHO).
29. WHO (World Health Organization). Hardness in Drinking Water : Background document for Development of WHO Guidelines for Drinking Water Quality,

WHO/HSE/WSH/10.01/10/Rev. 1, pp: 443-541 2011.

30. Koul N., Lokhande R. S. and Dhar J. K.; Physico-Chemical, Bacteriological and Pesticide analysis of Tap Water in Millennium City Gurgoan, Haryana, India, *International Research Journal of Environment Sciences.* Vol. 1(2), pp: 1-7,2012.
31. WHO (World Health Organization). Guidelines for Drinking Water Quality, Vol. 2 Recommendations, 2 Edn. Geneva, (WHO/PCS/96.48) 1996.
32. Basic Information in Nitrates in Drinking Water (BIS). Basic information about Regulated Drinking Water Contaminants, US-EPA-Environment Protection Agency , 2012.
33. Bernardo B.. Water pH and hardness affect growth of freshwater teleosts. *Revista Brasileira de Zootecnia* v.40, p.138-144, 2011.
34. Spade S. and Bristow B.. Effects of increasing water hardness on egg diameter and hatching rates of striped bass eggs. *North American Journal of Aquaculture*, v.61, p.263–265, 1999.
35. Hwang P. P., Tung Y. C. and Chang M. H.. Effect of environmental calcium levels on calcium uptake in tilapia larvae (*Oreochromis mossambicus*). *Fish Physiology and Biochemistry*, v.15,p.363-370, 1996.
36. Bijvelds M. J. C., Vander velden J. A. and Kolar, Z. I.. Magnesium transport in freshwater teleosts. *Journal of Experimental Biology*, v.201, p.1981-1990, 1998.
37. Flik G. and Verbost P. M.. Cellular mechanisms in calcium transport and homeostasis in fish. In: Hochachka, P.W.; Mommsen, T.P. (Eds.) Molecular biology frontiers biochemistry and molecular biology of fishes. Amsterdam: Elsevier,. p.252-263, 1995.
38. Steffens W.. Princípios fundamentales de la alimentación de los peces. Zaragoza: Acribia,. 275p,1997.
39. Kabir E. S., Kabir M., Islam S. M., Mia C. M., Begum N., Chowdhury D. A., Sultana S. M. and Rahman S. M.. "Assessment of effluent quality of Dhaka export processing zone with special emphasis to the textile and dying industries". Jahangirnagar Uni. J. Sci,. pp. 137-138,2002.
40. Boyd C. E. and Lichtkoppler F.. Water Quality Management In Fish Pond Culture. Research and Development Series No. 22. International Centre for Agriculture, Agricultural Experimental Station Auburn, pp: 30.1979.
41. Alam, M. J. B., Muyen Z., Islam, M. R., Islam, S. and Mamun, M. Water quality parameters alongrivers. *Int. J. Environ. Sci. Tech.*, 4 (1), 159-167, 2007.
42. Wedemeyer G. A. and Goodyear C. P.. Diseases caused by environmental stressors in O. Kinne (ed.), Diseases of Marine Animals, vol.4, part l: Introduction, pp: 424-434. 1984.
43. Post G. B.. Textbook of Fish Diseases TFH Publications, Neptune New Jersey, pp: 287. 1987.
44. Klontz G. W.. Environmental requirement and environmental diseases of salmonids. in M. Stoskopf (ed.), Fish Medicine. W . B. Saunders Phiadelphia Pennsylvania, pp: 333-342. 1993.
45. Kavka G. G. and Poetsch E.: Microbiology. - In: Technical Report of the International Commission for the Protection of the Danbue River. Eds. Péter Literáthy, Veronika Koller Kreimel, Igor Liska. Eigenverlag ICPDR. Pp: 138-150,2002.