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Studies on the Suitability of the Hiran Minar for Fish Culture and Interrelated Activities

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Abstract

Hiran Minar is a monument of Mughal Empire. It is located in distt. Sheikhupura and is 45 km to the north west of Lahore. Emperor Jhangir, in the memory of his the dearest deer (Mansraj), erected this monument and is named Hiran Minar (Hiran means deer). Later on, Shah Jahan Mughal Emperor (son of Shah Jahangir) built a square water reservoir adjacent to this monument. This reservoir with octagonal pavilion served as drinking water source for royal animals. Presently Government controls these installations along with all the ongoing activities. Punjab Fisheries Department stock in this reservoir and utilizes it for fish production. Archaeology Department is taking care of the brick building portion. Punjab Fisheries Department invite professional anglers and hold the fishing competitions in that reservoir. The children swim in this reservoir while women from the nearby villages wash clothes. People from the nearby villages bring their livestock to this reservoir. They drink water and take baths. Most of the people go there when they are free. Some of them enjoy picnic and boating. From the last few years, the villagers were complaining about this reservoir. They reported about the denial of their animals towards this reservoir. If by hook or crook they visit this reservoir they feel uncomfortable. They suffered from loose motions and refused to eat fodder. Fisheries Department has its complaints.They reported that fish appeared lethargic, it did not grow properly, majority of fishes died. Fishes displayed aberrations and spots on their bodies. Irrespective of the season of the year oxygen depleted frequently. Therefore, studies were conducted to explore the probable reasons that induced such uncommon outcomes in the reservoir water.Data collected showed unusual changes in the composition of water.Quality of water became unsuitable for fish culture and livestock visits. Even it was inappropriate for bathing, swimming and washing activities of the human beings.

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Introduction

Hiran Minar is built by Shah Jhangir in Sheikhupura. It is 45 km in the north west of Lahore. Hiran means deer. As emperor Jhangir erected this monument in the memory of the dearest deer 'Mansraj' hence since then it is commonly called Hiran Minar. This minaret is 100 ft high. Later on, Shah Jahan (son of Jhangir) built a square water reservoir adjacent to this monument. This reservoir looks like an octagonal pavilion. with octagonal pavilion in its center. In the middle of this reservoir overhead brick path leads to pavilion. There are ramps in surround walls that facilitate the entry of nearby animals and visitors who go there for picnic point of view. During the Mughal reign royal animals used to drink water from this reservoir. Currently this reservoir is a source of drinking water for livestock from the nearby villages. Moreover, human population frequently visits this site for swimming, boating and some women for washing clothes. Facilities available in and around this monument entertain and amuse the visitors.

This complex has several attractions that attract the visitors. Water reservoir, its collection system, grave of the deer and small square buildings (approximately 750 × 895 feet each) erected at each corner of the water reservoir are the most important. Mughal emperor dug a canal to supply water to this reservoir that abandoned later on due to its poor maintenance. Now Archaeology department has installed electric tube well that pumps underground water to this reservoir (Habibulla, unpublished data). Nonetheless when required they can also use small water distributary to filling it up. Punjab Government looks after and utilize these installations. Punjab Fisheries Department stocks fish in it and is auctioned when it attains table size. Archaeology Department looks after and maintains the brick-built portion. Fisheries department also hold fishing competition in addition to issuance of regular license to anglers for daily angling purposes.

From the last few years' villagers complained about the denial of their livestock to visit this reservoir. If accidentally they entered the reservoir and drank water they felt uncomfortable. They experienced loos emotions and refused to eat fodder. Similarly, Punjab Fisheries Department observed diseased fish following heavy mortality. The dead fish displayed spots and aberrations on the body. Remaining grew very poorly and was quite weak. Oxygen depletions were very common. This happened throughout the year at temperatures of >18 ^{0}C when it stabilized. Water smelled foul. Deposition of variety of pollutants was very much obvious that spoiled the environment of the reservoir and inflicted harmful effects on bot aquatic and terrestrial fauna and flora (Sjobeck *et al*., 1984). Therefore, purpose of the present studies was to explore the possible causes of unusual changes in water quality of this reservoir that deterred the livestock from entry in the reservoir, caused diseases and mortality in fish and retarded its growth.

Methadology

Study Site: Water reservoir adjacent to Hiran Minar was the focus of our study. Its water was analyzed for biological, microbiological, physical and chemical profile.

Microbiological analysis

Water and silt samples were carefully collected from the water reservoir in polythene bags. After sampling bags were well sealed in a cooler box containing ice packs at 4-10 ^{0}C and dispatched to laboratory for detailed analysis. Samples were allowed to settle for 20 hours prior to the initiation of the analytical work (Roberts *et al*., 2001). Because both water and silt were very dense hence each sample was diluted 10 times for convenient analysis and accurate estimation (Taulo *et al*., 2008). All the analytical work was completed in PCSIR Laboratories Lahore, Pakistan. Sterile Buffered Peptone Water BPW containing 0.1 % peptone + 0.85% Sodium Chloride (Na Cl) (CMO 509: Oxoid, Basing-Stoke, London, UK) was used for dilution of samples.

Biological Analysis

The samples were kept in the laboratory for 24 hours for their settlement. Supernatant was continuously removed until whole sample was reduced and maintained at 10 ml concentrate. From each concentrated sample 5 drops were picked, placed under binocular microscope and observed for qualitative and quantitative estimation of bacterial fauna with calibrated eyepiece. Methodology of (Navaro, 1981) was used for identification of aquatic life while for enumeration purposes (Lackey, 1938) Microtransect Drop Count Method, was used.

Physico-chemical Parameters

DO meter Model 9173 Jenico was used for determination of dissolved oxygen concentration. PH of water was determined by WTW series Ionolab 735. For estimation of remaining water quality parameters standard methods of APHA were applied (2005) (Table 1).

Table 1: *Chemical analysis of reservoir water*

Parameters	Units	W.H.O. Standards	Meade Standards (1989)	Water from the corner	Water from the ramp
Color	P.C.U.	5-50		<5	<5×±±
Taste	-	Harmless		Unpleasant	Harmless
Odor	-	-do-		Obnoxious	Odorless
Turbidity	N.T.U.	5-25		<5	<1
pH	-	7.0-8.5	6.5-8.0	7.6±0.3	7.4±0.2
Conductivity at 25 °C	µS/cm	-		260±27.6	239±25.2
Ammonia (NH_3)	ppm		<0.02		
Copper (Cu)	-do-		0.006		
Selenium (Se)	-do-		<0.01		
Silver (Ag)	-do-		<0.003		
Zinc(Zn)	-do-				
Total dissolved solids(TDS)	ppm	1500	<400	182±15.1	167±12.7
Total suspended solids (TSS)	-do-	-	<80	23±3.1	20±3.0
Total hardness($CaCO_3$)	-do-	500	10-400	123±9.2	120±10.3
Calcium	-do-	-	4-160	50±4.2	85±6.1
Magnesium	-do-	-		73±7.5	35±3.5
Calcium (Ca^{+2})	-do-	200		20±2.1	34±3.7
Magnesium (Mg^{+2})	-do-	150	<15	18±3.5	9±1.7
Total alkalinity($CaCO_3$)	-do-	500	10-400	95±10.1	84±8.7
Dissolved Oxygen(DO)	-do-	-	>5	9±1.2 in May	84±8.7
Bicarbonate(HCO_3^{-1})	-do-	-		116±10.2	102±10.0
Chloride(Cl^{-1})	-do-	600		16±2.1	21±3.1
Sulphate (SO_4^{-2})	-do-	400	<50	35±3.4	30±3.0
Sodium(Na^{+2})	-do-	-	75	13±2.5	11±1.2
Potassium(K^{+1})	-do-	-	<5.0	2.3±0.5	2±0.6
Iron(Fe^{+2})	-do-	1.0	0.1	0.06±0.01	0.03±0.0
Nitrite(NO_2^{-1})	-do-	0.5	0.1	<0.01±0.001	<0.01±0.002
Nitrate(NO_3^{-1})	-do-	50	0-3.0	0.05±0.001	0.05±0.003
Silica(SiO_2)	**-do-**	**14**		**3±1.2**	**3±1.0**

Where P.C.U. = Pollution Control Unit and N.T.U. = Nephelometric Unit

Statistical analysis

No well-established statistical experimental design was applied to these studies. Studies were only observatory. Purpose was to observe and assess the quality of existing water and bottom silt. It was conceived to devise the methods for the improvement of this reservoir making it a useful entity for nearby villagers and their livestock as well as for those who visit this reservoir for enjoyment. At the outset it was also apprehended to develop the future guidelines for the safe utility of this asset for fish and livestock. Hence statistical analysis was limited to sample means only. Complicated statistical tests were out of the scope of these studies. Hence such tests were neither desired nor applied.

Results and Discussion

Depending on the nature and source of water it harbors variety of useful bacteria as well as pathogenic life. Microscopic fauna present in water cause variety of ailments in human beings and in livestock that utilize this water in one way or the other. Intensity and symptoms of such ailments are quite common and well documented in both developed and developing countries (Younes and Bartram, 2001; Wright *et al*., 2004) and accordingly has become a global issue (UNESCO, 2003). It is equally applicable to both human beings and livestock. Pathogenic microscopic fauna and toxic elements in water or bottom sediments are blamed for outcomes of these ailments. It is not a universal rule however. If concentration of these agents quite low and below the harmful level they do not harm any life may be smaller or bigger. There are variety of sources that deteriorate water quality of running and stagnant water. Domestic and agricultural wastes are always the major ones. Sometimes these effluents come from waste water. Some harmful plants and fecal sources also deteriorate water quality and bottom silt. Limits of these loathsome pathogens and /or elements are well established (W.H.O., 2003) (Meade, 1989).

These standards are reasonable guidance for safe use of these resources (Table 1 and 2). Our studies displayed very useful and reliable values indicative enough the harmful effects of these parameters for both human beings and livestock and were quite in line with these standards. Our studies displayed a very reliable evidence to deter livestock owners, and other human beings to obstinate entry in this reservoir and its utilization for various purposes.

Table 2: *Microbiology of water and bottom silt*

Plate Count	Category of sample	
	Ramp water	**Bottom silt**
Total plate count ml^{-1}	$9.1×10^5±1050$	**$2.6×10^6±11$**

Total coliforms (MPN 100 ml^{-1})	46.0±5.2	**130.0±7.6**
Fecal coliforms (MPN 100 ml^{-1})	46.0±4.3	**79.0±6.5**
***E.coli* (MPN 100 ml^{-1})**	46.0±5.7	**79.0±7.2**
***Salmonella* sp. 25 ml^{-1}**	Detected	**Infected sample**
***Aeromonas* sp.**	N.D.	**N.D.**
***Vibrio* sp.**	N.D.	**N.D.**
***Staphylococcus aureaus* ml^{-1}**	N.D.	**N.D.**
Yeast count ml^{-1}	3.1×10^{1}±4.5	**1.5×10^{3}±200**
Mould count ml^{-1}	**1.2×10^{2}±8.2**	**3.4×10^{4}±2050**

Coliforms, *E. coli* (bacterial sp.), yeast and mold (fungal varieties) were quite common in both water and bottom silt. Concentration of these pathogens was comparatively higher in bottom sediments. *Staphylococcus aureaus, Aermonas* and *Vbrio* were absent (Table 1). *Salmonella* were in very low concentration and were difficult to quantify. It is common in farmed and wild fish. Hence it is taken a s good indicator of polluted water (Sechi *et al*., 2002). *Vibrio* and *Aeromonas* were observed in abundance in Alcantara river in abundance. Scientists declared them as fecal indicator (Guliandolo *et al*., 2009). But ratio of both bacteria did not coincide with each other that made the findings inconclusive. Contradictory to previous studies presence of bacteria and fungi displayed the level of pollution and their relative increase or decrease well corroborated with each other (Table 1) that differed well from past explorations (Guliandolo *et al*., 2009). Morris(1978) in his studies recommended coliform free water for human. He further reported that water with coliform level of 100-200 ml^{-1} is acceptable for recreation purposes.

He recommended quite higher coliform levels of 5000 for fish and wildlife while he suggested quite lower levels of 14 for shellfish. Warrington (2001) however well differed from Morris (1978). Warrington recommended levels of *E. coli, Enterococci,* and fecal coliform should not exceed a median MPN of 14 100 ml^{-1}, 4 100 ml^{-1} and 14 100 ml^{-1} for human consumption respectively. In contrast to human beings he opined total absence of *E. coli*, *Enterococci*, *Pseudomonas aeruginosa* and fecal coliform from drinking water for livestock. However, he recommended different levels for crops. He suggested maximum levels of 200 100 ml^{-1}, 77 100 ml^{-1} and 20 100 ml^{-1} for coliform, *E. coli,* and Enterococci respectively. These values were quite higher than these values that dictates that reservoir water of Hiran Minar is totally unfit for fish, livestock, and human beings. Though W.H.O.(2003) suggests quite flexible limits for the presence levels of these bacteria and according to their recommendations some waters may be suitable for animals and human beings but our studies totally contradicts and strongly rejects this water for utilization of routine and common activities. Because according to our biological analysis there is very narrow margin to escape from these limitations.

Euglena, Microcysts, Volvox, Spirogyra, Oedogonium and Oscillatoria were the common phytoplankton in this reservoir. Presence and distribution of these plants was quite variable with the season of the year. Maximum population of these plants was observed during the months of February-April, and then from June-October. These phytoplankton peaked the months of June and July, their growth declined gradually and they were totally absent in November, December, and January. In January concentrations of Cyano were quite higher in January than eukaryotes in January. Nonetheless there was rise in the ratio of eukaryotes to cyanobacteria in July. Potuzak (2007) in his studies eutrophication is always undesirable in natural waters. This process induced uncontrolled and harmful primary productivity mainly inedible cyanophytes. Such microscopic plans are harmful for fish. These observations favorably. These findings support our explorations and further dictates that sudden burst of pico phytoplankton indicates eutrophication. This eutrophic water causes drastic fluctuations in oxygen levels of the water with the lowest oxygen levels in the early morning hours causing massive fish kills (Ashraf unpublished data).

In addition to phytoplankton groups of Zooplankton indicates status of water quality. At the same time, they are good source of food for both juvenile and adult's fish and considerably supplement artificial feed and in some cases significantly decreases the requirement of artificial feed -an expensive component in fish farming practices. Their concentration enormously vary both qualitatively and quantitatively during eutrophication and pollution (Sakesena, 1987). Their feeding behavior of these zooplankton categorize them in grazers, suspension feeders and predators (Rogozin, 2000). Our analysis displayed presence of *Cyclops*, *Daphnia*, *Brachionus*, *Rotatoria*, and *Macrothrox*. *Asplanchna* as principal zooplankton. Like phytoplankton protozoans, rotifers and crustaceans were dominant in October. Daphnia however contradicted and they were dominant throughout the year. Paramecium however differed from all the other zooplankton. It was predominantly observed from December to May. *Brachionus* however showed total different behavior from other zooplankton. It was completely absent in water under study during the months of July, November, December and January. Apparently, this behavior shows its intolerance to temperature extremes whether cold or hot that vanishes it entirely. Disrupted presence of zooplankton in this reservoir indicates that each and every group has different temperate tolerance capabilities. Unlike other groups *Asplancha* was totally absent in August. Unlike *Asplancha* Cyclops were observed only in moderate season from January to March. Their appearance and growth proportionated to the rise of temperature in February. Their population peaked in April and then started to decline. Daphnia population remained persistent as well as abundant throughout the year.

The findings of Stiling (1996) and Yigit (2006) substantiate our observations in the distribution and presence of zooplankton. They in their studies reported that the presence of Cladocerans and *Rotifera* in spring, summer, autumn and winter though their popular descended later on. They also reported the presence, persistence and abundance of the Daphnia throughout the year that further support and validate our explorations on this water reservoir. These and our studies warrant that Daphnia least care about water quality. It can successfully survive, flourish and grow in poor quality waters. Outcomes of studies of Potuzak (2007) and ours congrue at common Point.

Results of both studies develop a consensus that nauplii, cyclopoid *Copepods*, *Cladocera* and rotifers can successfully thrive in low nutrient water. Physical and chemical quality of water also matters least for their growth. Eutrophication in any case may be in the past or in our situation is injurious to the production of quality phyto and zooplankton. It always promotes primary productivity with abundant inedible cyanophytes. This scenario not only create hazards for aquatic fauna rather further ameliorates the situation by exploiting physical and chemical water quality.

Table 3: *Chemical analysis of selected water quality parameters at various times of the year*

Month	**Water Quality Parameters**								
	Hardness (ppm)	**Ca^{++}** Ppm	**Mg^{++}** ppm	**$CO3^{--}$** ppm	**Cl^{-}** ppm	**NO_3^{-}** ppm	**PO_4^{--}** ppm	**TDS** ppm	**Alkalinity ppm**
March				212 ±10.0					
Ist fortnight								227± 15.1	
IInd fortnight									
April		52±5.2							
Ist fortnight									
IInd fortnight		48±5.0							
May									
Ist fortnight					7 ± 2.5				
IInd fortnight									

June								**121±10.5**
Ist fortnight		25±3.						
IInd fortnight		2			0.102			
					±0.01			
July								
Ist fortnight			110±					
IInd fortnight			6.5					
August				63±6.				
Ist fortnight				5		0.000		
IInd fortnight						9±0		**70±8.6**
September	200	N.D.						
Ist fortnight	±12.					0.000		
IInd fortnight	6					2±0.0		
January					0.056			
Ist fortnight					±0.00			
IInd fortnight					2			
February								
Ist fortnight	**78±**						**116±**	
IInd fortnight	**8.7**						**6.2**	

Nitrates were higher in June and low in January. All the other elements and compounds were found in acceptable ranges (Table 2). Presence level of phosphates differed from that of nitrates. Unlike nitrates phosphates were higher in August and lower in September that may vary with their level of production and consumption during different seasons and months of the year (Table 3). The possible reason of fluctuations in the presence of their concentration with changing season of the year may be due to the different levels of photosynthesis that keep them in suspension as per its requirement. Carbonates in water buffer the media. Their concentrations were higher in March and low in July. It looks that their utility was low in March and it's increased with rise in temperature because it has to stabilize abrupt and undesirable changes in pH during high temperature and subsequent peak photosynthesis period. Though other water quality parameters also varied with the change in season (Table 3) but they did not show any deleterious effects on water quality (Table 3). During 2000 Mudassara also analyzed the water of this reservoir. She reported that the concentrations CO_3^{--}, Ca^{++}, Mg^{++}, Cl^{-}, NO_3^{-}, PO_4^{-}, TDS, alkalinity and hardness vary during the different time periods of the year. Such variations were less drastic during the winter seasons and more prominent during the shot months of the year.

Findings of Mudassra (2000) favorably correspond to ours. Both merge at common point that water was nutrient rich and eutrophication was quite common and frequent at least during hot season. Hence eutrophication was dangerous for fish and nutrient rich waster was injurious for nearby livestock. During her studies there was lot of variability in pH during summer and winter months of the year. PH value was

5.5 during the 1st fortnight of June and 8.4 during the 1st fortnight of January. Her and our studies show how the temperature variations drastically affect the quality of water impacting negatively both aquatic and terrestrial fauna. Such low pH levels are not acceptable for living flora and fauna as well as for healthy water quality. Low pH (<4.5) acidifies water and solubilizes some harmful metals. These metals suspend and accumulate in water. They cause heavy toxicity of water consumers and induce various pathological changes in the body of healthy life. Studies of Vinodhini and Narayanan (2009) have similar findings on *Cyprinus carpio*. They observed elevated red blood cells, blood glucose and cholesterol when they exposed this fish to combined sub lethal (5 ppm) concentrations of Cd, Pb, Cr and Ni. These metals decreased vitamin C activity in fish following per oxidation in fish tissues. As the only pH study was not our focus, neither we observe such drastic decreases in pH concentrations hence effects of pH were least studied and not well focused and addressed.

Elevated concentrations of DO were observed during the month of May (Table 2). This was due to eutrophication process in water reservoir. This always happens when water is nutrient rich and temperature is high. Algal bloom appears, and it increases unimaginably DO levels high. Reversal of this process takes place in the evening and oxygen decreases to critical level in early morning. Fish come at the surface and mass mortalities can be observed at that time. Our findings are quite in line with those of Ayoade *et al*. (2006). They also observed high DO concentrations in Asejire Lake during rainy season. Though temperature was moderate at that time that have little effect on plant growth. Photosynthesis peaked as usual due to excessive deposition and accumulation of nutrients in the lake. Similar to our studies Potuzak (2007) found high eutrophication in water reservoir under his studies. Accelerated rate of eutrophication induces primary productivity. Inedible cyanophytes, dominated and disturbed the basal water quality parameters. Our studies verified the past ones because due to the presence of excessive nutrients eutrophication occurred it not only critically disturbed the DO levels but severely deteriorated other water quality parameters.

During their studies on red drum, *Sciaenops ocellatus,* Pursley and Wolters (2007) reported that 500 ppm Cl^- and 400 ppm hardness favored the growth and survival of this fish. Nonetheless they did not observe any interaction between both these nutrients and both worked independent to each in the production of primary productivity. Similar to the former studies Adeyemo *et al*. (2008) observed phosphate (2.23-16.2 ppm) and 0.35-2.8 ppm; nitrates 0.22 to 0.9 ppm and 0.47-3.3 ppm; nitrites (0.2-0.42 ppm and 0.03-0.3 ppm; total nitrogen (0.13-0.9 ppm and 0.47-3.4 ppm) and sulfate (70-99.4 ppm and 26.6-120 ppm) respectively in Ibadan River System respectively. They observed and explored these values in dry as well as in rainy season for comparison purposes and also find out if rain showers have any positive or negative effect on the nutrient load of water in this river. Gugliandolo *et al*. (2009) on the other hand found out DO 5.22 ppm in July and 8.9 ppm in October, nitrates 1.23 in May and 2.59 ppm in October and total phosphorus from 0.07 in May and 0.24 ppm in October. All these parameters were in quite better position in October that might be due to low rate of photosynthesis that allowed the nutrients to stay suspended in water. Situation however was different in our studies where we observed levels of chloride and hardness only 123 and 16 ppm respectively (Table 2). These levels were quite inadequate to support desired natural food to support fish growth. Like these nutrients levels of other nutrients were also quite low that probably happened due to continuous and extensive occurrence of eutrophication that they did not allow to settle them in water or in the sediment in measurable position and those were unable to support useful productivity (Table 2).

After oxygen ammonia is the second most important limiting factor affecting survival and fish growth. Its importance further materializes when our fish farming move from extensive to intensive set up (Francis-Floyd *et al*., 2009). Ammonia even in very minute concentrations stresses the fish, damages gills and other tissues. Fish become more susceptible to bacterial infections, its growth retards, and it performs very poorly during handling. Like ammonia, Methane (CH_4) and hydrogen sulfide (H_2S) are two other gases that severely harm fish and considerably damages the wellbeing of fish and overall fish production. These gases cause obnoxious odor and might have deterred the livestock to approach this reservoir with subsequent production symptoms of sickness in livestock. During the current studies due to lack of required facilities these gases were not tested. Further studies are required on the biotic features of water. It is required to assess whether it is contributing to the emission of greenhouse gases from the tank water and bottom silt.

Our findings dictate that water of this reservoir is totally unfit for the routine activities that may be washing of clothes or visiting of livestock for bathing and drinking water. Moreover, it is quite unsuitable for fish that is living inside as well those who consume it because it will deposit lot of injurious nutrients in its body and will be passed on to the consumer.

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