MADHYA PRADESH
WATER RESOURCES DEPARTMENT

WORLD BANK AIDED
HYDROLOGY PROJECT PHASE-II

Purpose Driven Study

"The Impact of Contaminated Shahpura Lake on Ground Water Environment, Bhopal, MP"

FINAL REPORT

Chief Engineer (BODHI)
Water Resources Department
Bhopal, (MP)

Purpose Driven Study

"The impact of Shahpura Lake on Ground Water Environment, Bhopal"

Implementing agency	: **Water Quality Laboratory, Level II^{+} Ground Water Survey Circle, Water Resources Department, Bhopal**
Associated Institute	**: Department of Environmental Science and Limnology Barkatullah University, Bhopal**
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Under the World Bank Aided Hydrology Project Phase II, Purpose Driven Study was taken up for developing a user friendly monitoring technique to support the water sector planner and administrators to protect water bodies and provide potable quality of ground water abstracted from its fringe area. Main objective is to study the ingress of sewage contaminated lake water into ground water and to tie up the Limnological data with ground water quality. Collection of sample was initiated from May 2010 to October 2012 from ground water located at upstream and downstream of water body, and lake water samples at different locations coordinating the groundwater sites. Water quality parameters mainly nutrients, organic matter along with Limnological observation viz. Phytoplankton/Zooplankton and benthos density and diversity, chlorophyll estimation, sediment analysis, status fisheries, macrophytic diversity and GIS mapping were carried out for better management plan and DPR preparation. The complete data analyzed using Prati and BMWP indexing by the ground WQ Laboratory Bhopal and compiled in this document carried till October 2012.

S. S. Roy
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PROJECT AT A GLANCE

S No	Description of items	Details
1	Date of approval	06 August 2010
2	Date of completion	30 November 2012
	Study area	Shahpura lake basin
	Toposheet	55E/8
	Catchment area of lake	8.29 Sq. Km
	Submergence area	0.96 Sq. Km
	Gross storage	2.2 m. cub.
	Live storage	2.07 m. cub.
	Max. Water level	489.00 m
	Geological formation	Vindhyan Sand Stone & Deccan Trap Basalt
	Existing abstraction shallow tube wells : Purpose driven Peizometers : Shoreline surface water locations : Depth surface water locations :	- 16 Nos. - 10 Nos. - 13 Nos. - 12 Nos.
	Major source of surface water contamination	1. Kotra Main Drainage (North) 2. Charimli Drainage (North - East) 3. Shahpura drainage (East-South) 4. Dhobi Ghat (Eastern side of Lake)
	Main use of lake water	Washing, bathing, recreation, aquaculture
	Major source of drinking water in fringe area	Ground water using motorized tube wells
	Type of water body	Eutrophic
	Socio economical features	Well educated, understanding of environmental degradation
	Local impact on GW quality in fringe area	Lined drainage/sewage disposal system

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Summary:

Due to insufficient surface water supply, ground water is the main source of drinking water supply in the Shahpura lake basin study area. Downstream south-west region "Chuna Bhatti" residential area is the recharge zone of the Shahpura lake and the tube wells and dug wells located close to the Shahpura lake in both upstream (near Administrative Academy) and downstream (Chunna Bhatti area), groundwater quality demonstrated major deterioration in its quality due to presence of toxic Nitrate, Phosphate, Organic matter, pathogenic bacteria, for which the possible source is the sewage contaminated lake water. ***Municipal septic disposal system are well lined and the residents belonged to higher socio economic class and well versed with the environmental issues therefore possibility of any local effect on ground water quality was negligible***.

As the houses located around the watershed rely on individual well water supply, so to protect the human health, it was found necessary to monitor the progressive degradation in ground water quality of the wells as well as the surface water characteristics of Shahpura lake. The output may be helpful to identify the management plan for providing safe drinking water and also to protect the water body and its ecosystem from further possible damage.

A total duration of this project is 3 year and Limnological study was carryout one year from November 2011 to October 2012

Total 25 surface water sampling sites were studied under the PDS at different location (depth and shoreline) at Shahpura lake. A total of **522 samples** were collected and analysed mainly for pollution parameters Ammonical Nitrogen, Nitrate and Phasphate (NH_3-N, NO_3^-N, PO_4) and organic matter along with pH, electrical conductivity (EC), total dissolved solids (TDS), Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^- and Na^+, K^+.

The Shahpura Lake which is supposed to be a possible source of contamination of ground water in its fringe area was reported having very rich nutrients value such as nitrate and phosphate along with ammonical nitrogen toxicity and organic matter in north eastern and north western side, where the raw sewage from Kotra drainage, Charimli drainage and Shahpura drainage as point source is mixing into the water body, to the maximum of 37.5 mg/l, 9.0 mg/l, 10 mg/l, 92 mg/l and average value 27.74 mg/l, 4.06 mg/l, 5.2 mg/l and 67.86 mg/l respectively.

Similarly stations located also reported high nutrient value (nitrate and phosphate) along with ammonical nitrogen toxicity and organic matter to the maximum of 36.6 mg/l, 4.0 mg/l, 10.0 mg/l, 123 mg/l and average value as 26.43 mg/l, 2.05 mg/l, 4.08 mg/l, and 80.76 mg/l respectively. Therefore it is observed that the overall quality of water body is highly polluted and unsuitable for drinking, domestic, bathing and recreational uses. The high contaminants level is also detrimental to fish cultivation and its growth and turning the water body eutrophic.

Total 25 no. ground water samples in the fringe area of water body mostly used as source water for drinking and community supply were collected from **15 no private shallow tub wells/dug wells and**

newly built 10 No. purpose built Peizometers (30 mtr depth) within the periphery of 600 mtrs from lake. A total of **409 GW samples** were collected and analysed for mainly nutrient contamination viz Nitrogen as Ammonical nitrogen (NH_3-N), Nitrate (NO_3), Phosphorous as total Phosphate (Total PO_4), Organic matter as Chemical Oxygen Demand (COD), pH, and also other physical and anthropogenic elements viz. electrical conductivity (EC), total dissolved solids (TDS), Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, F^- and Iron (Fe^{++}). Presence of colliform bacteria were also reported in ground water mostly in the downstream of water body situated in its southern part.

Upstream well water: Out of 15 ground water of upstream (north-west and north west side) reported having very rich nutrients value such as nitrate and phosphate along with the organic matter to the maximum value of 66.4 mg/l, 0.42 mg/l, and 52.8 mg/l and average value of 29.30 mg/l, 0.23 mg/l, and 18.56 mg/l respectively. 6 upstream peizometric well water situated both at north-west and north west side of lake reported Ammonical Nitrogen toxicity above its permissible limit of <0.3 mg/l, with a maximum value of 2.25 mg/l and an average of 0.63mg/l NH4-N.

Downstream Well water: Similarly stations located at south-west side of lake also reported high nutrient value (nitrate and phosphate) along with organic matter to the maximum of 109.2 mg/l, 1.0 mg/l and 64 mg/l and average value of 26.99 mg/l, 0.26 mg/l and 14.95 mg/l respectively. Whereas 7 domestic wells located at downstream to waste-wear with massive basaltic sand stone formation reports low contamination

Prati index of surface water based on the average value of 6 parameters namely pH, Dissolved oxygen, Biochemical demand, Chemical demand, Nitrate, Ammonical nitrogen, and Phosphate establishes that 77% samples comes under doubtful and 23% under badly polluted category. Overall lake water quality is in the category of unsuitable water class.

3 peizometer well at downstream reported maximum of 3.05 mg/l of ammonical nitrogen with an average value of 1.08 mg/l NH4-N.

11 No. domestic GW stations out of 15 stations reported presence of organic matter greater than its permissible value of 10 mg/lit Chemical Oxygen Demand (COD) with highest value of 64 mg/Litre and phosphate 1.0 mg/l at G11-A (Downstream South west), average value 17.80 mg/lit during post monsoon. The presence of organic matter in ground water flow establishes impact of contaminated surface water on ground water environment and putting the ground water unsuitable for both drinking and domestic use.

Therefore observing the overall range of above mentioned contaminants in well water at both downstream southern side (Chunna Bhatti residential area) and upstream north western side (Amrapali enclave) and north eastern side (Near Academy building) of the lake, ground water are found contaminated from external sources.

Prati index of ground water based on the average value of 3 parameters namely Chemical oxygen demand, Nitrate and Phosphate establishes that 33.33% samples comes under doubtful and 63.60% under slightly polluted category. Overall lake water quality is in the category of unsuitable water class.

In biological observation total 150 phytoplankton species was reported belonging to 5 groups namely, Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae .Group Chlorophyceae had the highest number of species (52 species) followed by Euglenophyceae (34 species), Bacillariophyceae (32 species), Cyanophyceae (29 species), and 2 species were varied between 10.5 to 2560 individuals/l. therefore 28 pollution indicator species was observed with rich density in the lake. The maximum density of phytoplankton observed in southern part of the lake.

62 species of zooplankton was recorded where as group Rotifera had the highest number of species (43 species) followed by Protozoa and Cladocera (6 species), Copepoda and Cyclopoida (3 species), 1 species of Ostracoda. The zooplankton density of Shahpura lake were varied between 740.5 to 1328 individuals/l. in Shahpura lake following pollution indicator species was observed *Lecane sp., Brachionus calyciflorus, B falcatus, B quadridentatus, B budapestinensis, Asplanchna brightwellii, Filinia sp., and Daphnia sp* species were pollution indicator and among

A total of three phylums were noted during the entire study period viz., Arthropoda, Mollusca and Annelida. A total number of 43 species were recorded from Shahpura lake come under Arthropoda was dominant phylum with 25 *sp*. followed by Mollusca with 13 species and Annelida with 5 species. The density of benthos of lake is 9866 – 31111 org/m^2. The main dominance species of Arthropoda (group Insecta) namely *Chironomus, Ablabesmyia,Hydropsyche, Limnephilus, Proclalius, Amphiagrion,Culicidae pupa,Hesperocorixa,Notonecta.*Five species of Annelida namely *Branchiura, Lumbricullus,Glossiphornia complanata, Glossiphornia leteroculata, Helobdella stagnalis* andthemost dominant benthic species of Mollusca (group Gastropoda) namely *Bellamyabengalensis,B. crassa, B. crassispiralis, B. dissimilis,Indoplanorbis exustus, Physa,Thira tuberculata.* The maximum pollution indicators species was observed in southern part of the lake having rich density.

Total 11 species of macrophytes were reported during the study period. There were 2 species of submerged *Najas minor, Hydrilla verticillata,* 2 species of free floating *Pistia stratiotes, Eichhornia crassipes* and 7 shoreline species namely *Polygonum glabrum, Cyperus articulatus, Sagittaria sagittifolia, Begrgia cappensis, Nymphaea nouchali,Phragmites carka, Typha sp* were recorded.

During the study period 6 culturable species of fishes i.e., *Catla catla, Labeo rohita, Cirrhinus mrigala, Hypophthalmichthys molitrix* (Silver carp), *Cyprinus carpio* (Common carp), *Notopterus notopterus* and *Tilapia mossambica* was recorded. *Hypophthalmichthys molitrix, Cyprinus carpio* and Tilapia are exotic species. Tilapia is harmful for any aquatic system, having large size in Shahpura lake which was more than half kg. During the local observation and market survey this size of tilapia was not found in any other place of Madhya Pradesh. A total fish production as per the Shahpura fisheries society of shahpra lake 70% of tilapia and 30% of Indian major carps. It is clearly indicated that this aquatic system is fully disturbed**.**

Lake trophic status was assessed by using Nygards index shows Mixophycean highest value and Carlsons trophic index showed that the lake was hyper eutrophic (polluted). BMWP value reported heavy / severe pollution of Shahpura lake water.

1. Introduction:

Bhopal, the capital of the state of Madhya Pradesh is situated in the centre of India, at an altitude of 505 M above seal level (Fig.1.1a). The city is located at longitude 77°12' - 77°40' eastern and latitude 23°07' - 23°94' northern. It covers a total area of 284 sq km.

Due to insufficient surface water resources, ground water is the main water supply in the Shahpura lake basin study area. Down stream south-west region of the Shahpura lake "Chuna Bhatti" residential area is known as ground water sanctuary and used to ***supply untreated ground water*** through hundreds of tanks to Bhopal urban area during summer season. ***Abstraction of ground water is done using electrical motors***.

Shahpura lake is a man made water body and used to collect the storm flow water received from three major open drainage system called Kotra drainage north west side, Charimli drainage northern side and Shahpura drainage at eastern side of lake. The drainage system carry direct ***point source transferring*** the untreated municipal and house hold waste and human excreta/animal faeces and diffused urban source runoff from city streets, gardening and commercial activities in urban environment. ***Homes located around the watershed rely on individual well water and have well lined municipal septic disposal system***. Therefore possibility of any local effect on ground water quality was negligible.

1.1 Geology and Soil: The geological formations underlying the Bhopal area – at the eastern edge of the Malwa Plateau – are largely red sandstone strata, with the depth of the rock varying according to the slopes. The top portions of the hillocks generally consist of hard red soil, mixed with basaltic boulders. Black cotton soil is seen at various depths from 1 to 3.0m

Geohydrological distribution in Shahpura lake basin: In catchment area of lake, north and north-western side lies deccan trap basaltic flow which have intertrapean bed or weathered basalt zone with water (aquifer) at 15 to 18 mtr below ground level. In this are 3 no peizometers are drilled.

Lake is situated on contact plain of vindhyan sand stone and deccen trap basalt. At downstream zone of south, south-east and south-west where lies vindhyan sand stone and deccan trap basalt 7 no peizometers have been established. which is nearly about 25 mtr to 28 mtr below ground level.

1.2 Lithology: The borehole cutting at regular intervals of two meters or whenever changes in formation encountered was observed. The general Lithologs of peizometers in Vindhyan Sand Stone Area and Deccan Trap Basalt area Area is given in Table -1.

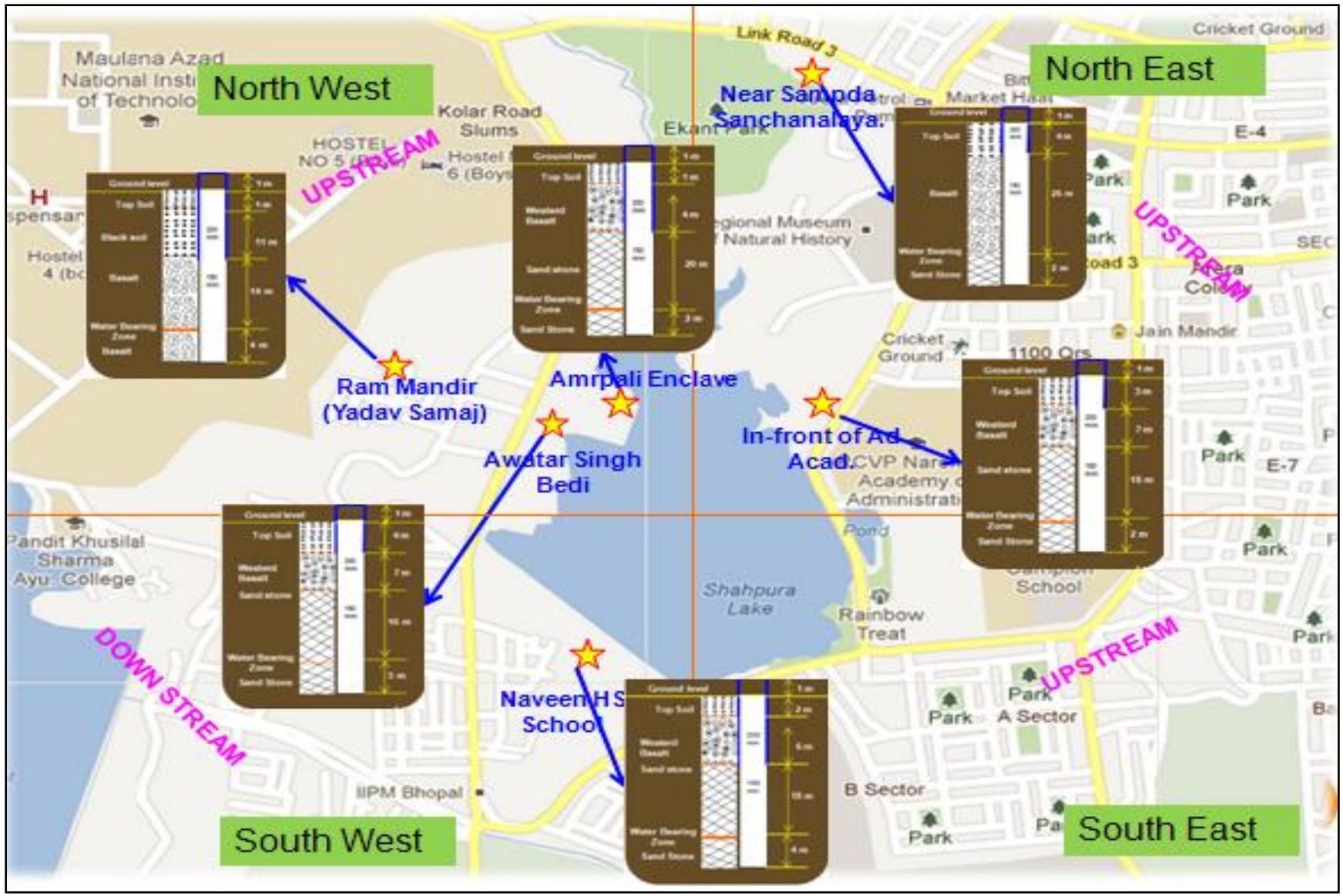
Table 1: Hydrological boreholes drilled in the catchment area of Shahpura Lake Basin

Drilled Depth (mbgl)	Average Depth of water level (bgl) – pre-monsoon 2011	Water bearing Horizon	Lithology
30.0 mtr	16.0 mtr (15 mtr to 18 mtr)	In Vindhyan Sand Stone Area	Weatherd Basult 0 - 6.15 Redbole 6.15 – 9.80 Vindhyan sandstone 9.80 – 21.30 Friable vindhyan sandstone compact 21.30 – 30.00
30.0 mtr	26.0 mtr (25 mtr to 28 mtr)	In Deccan Trap Basalt area	Weatherd Basult 0 2.6 Massive basault 2.6 – 10.7 Vasicular basualt 10.7 – 14.7 Redbole & weatherd basult 14.7 – 18.8 Vindhyan sandstone compact 18.8 – 30.0

1.3 Climatic Conditions: The city enjoys a moderate climate. Normally temperature ranges between 50oF and 104oF although highest temperature occasionally rises to 110oF. In such moderate climate, residential areas can be developed at higher densities as three to four storied buildings can be constructed without causing discomfort to the occupants.

The rainy season lasts from mid June to September, the winter from November to February, and summer from March to June. October sees the transition from rainy to the winter season. The average annual rainfall is round 1200 mm, falling predominantly during July and August. The average number of rainy days is approximately 40.

Map 1: Peizometers of Shahpura lake basin



2. Objectives of the P D S:

- Development of long term monitoring mechanism to keep vigil on progression of surface water pollution by studying systematic & periodically physic-chemical parameters.
- Monitoring of groundwater water quality to study ingress of chemical contamination into fringe area aquifer used for drinking water supplies.
- Study the impact of contaminants on biological diversity, tropic status of lake and identification of the indicator species.
- Tie up of Limnological data with ground water quality in the study area

2.1 Shahpura Lake

The study area Shahpura lake basin is situated in 23°12’25” latitude and 77°262’00” longitude and it covers total area of 98 hectare.Shahpura lake is located at the South East end of Bhopal. In 1974 the capacity of this small water body was increased by the construction of an embracement. Later on a drain that brings in the untreated domestic sewerage from the substantial part of new Bhopal city was impounded into this lake. The over flow from this lake meets the river Kaliasote, a tributary of river Betwa which ultimately is polluted by domestic sewage.

Upstream: Charimli and Shahpura residential areas are located at northern and eastern side of lake comprising of major drainage viz. Kotra drain at north western and Shahpura drain at eastern side.

Downstream: Planned residential area (Chuna Bhatti) at south - western side of the lake. At Shahpura Lake, the entry of nutrients was due to the use of detergents and the influx of sewage water from surrounding areas. It receives domestic raw sewage from surrounding habitation; so also the activities like cattle washing, cloth washing, bathing, religious activities like idol immersion etc. paves the way for high concentration of hazardous chemicals in the lake water. The untreated wastewater contains effluent rich in nitrogen, phosphate, caustic soda and detergent, etc.

Samples of groundwater and surface water were collected at monthly intervals and analysed for physic chemical and biological properties. Diversity and density of phytoplankton, zooplankton and benthos was also studied. Lake sediment samples were also collected for physicochemical analysis.

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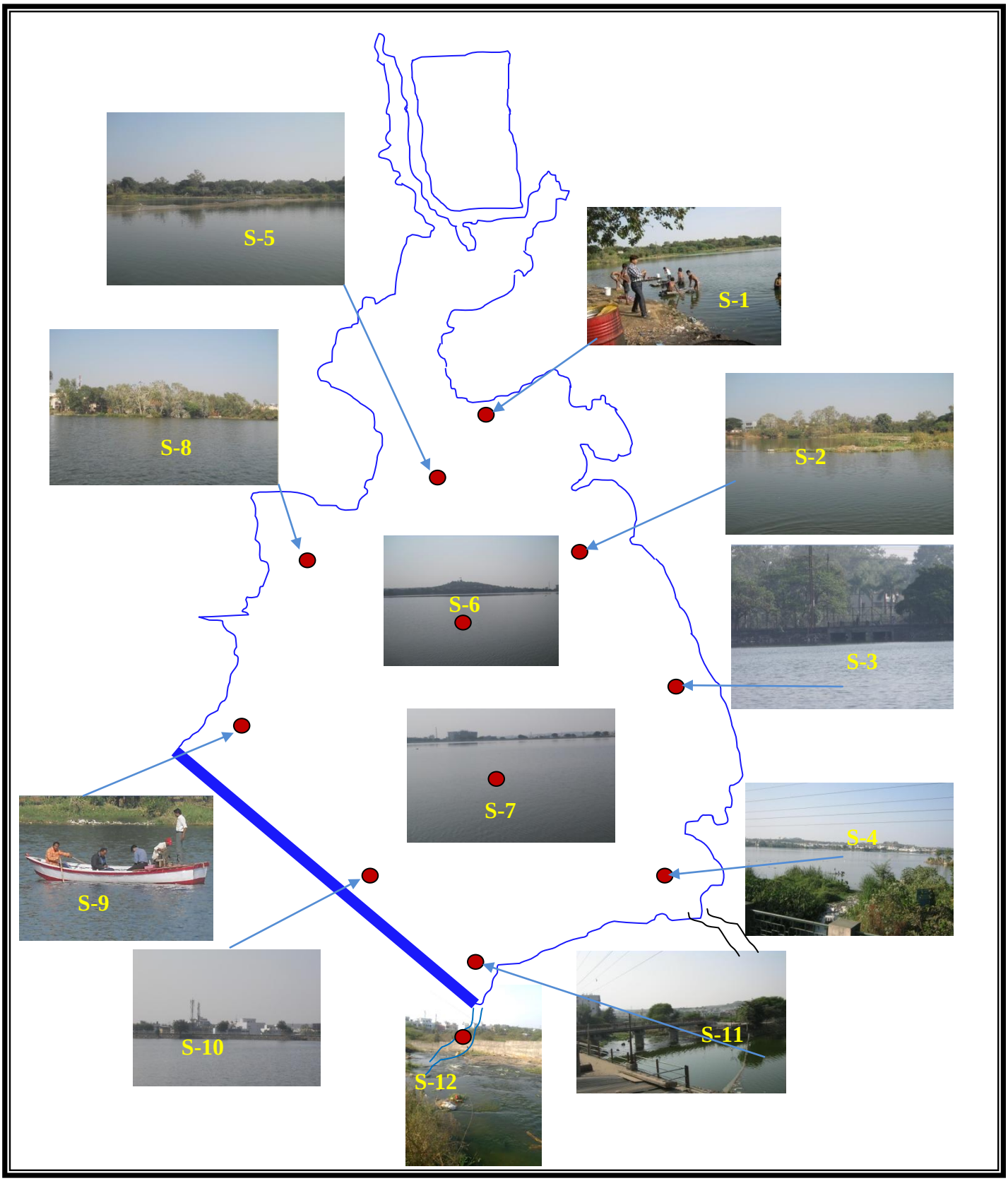
In this project following parameters are included for monthly observation, physico-chemical properties of water, sediment, phyto and zooplankton diversity and density, benthos density and density, Macrophytes and fish diversity of Shahpura Lake. The details are given in table 2 and 3.

Table 2: Details of Limnological observation sampling site in Shahpura Lake

Sites	Latitude	Longitude
Site-1: Dhobi Ghat near MPPCB:	23 12 30.5	77 25 18.1
Site-2: In front Admin. Acad.:	23 12 25.1	77 25 22.2
Site-3: Near park:	23 12 15.8	77 25 26.7
Site-4: Inlet of Shahpura nullah:	23 12 8.5	77 25 25.7
Site-5: Joining of nullah:	23 12 26.3	77 25 15.5
Site-6: Center of lake:	23 12 21.3	77 25 20.9
Site-7: Center of lake down side:	23 12 08.6	77 25 22.5
Site-8: Near CI villa:	23 12 22.2	77 25 09.8
Site-9: Starting of earthen dam:	23 12 12.3	77 25 06.5
Site-10: Center of earthen dam:	23 12 09.2	77 25 10.8
Site-11: Waste weir:	23 12 03.8	77 25 17.1
Site-12: Nullah behind New Friends colony	23 12 0.8	77 25 13.1

Map 2: Map of sampling site location in Shahpura lake



Map 3: Location map of Shahpura lake basin under HP-II PDS, Bhopal

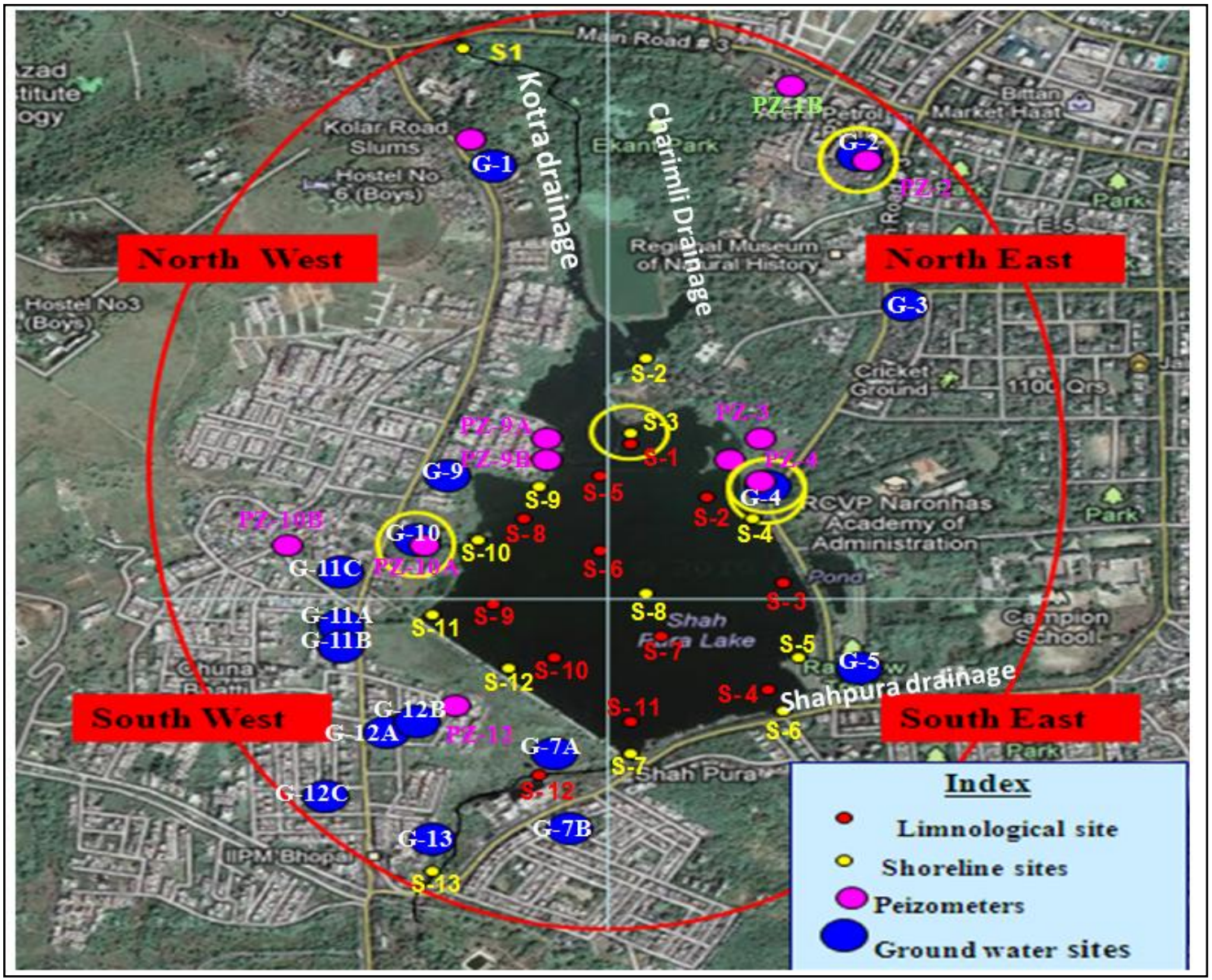
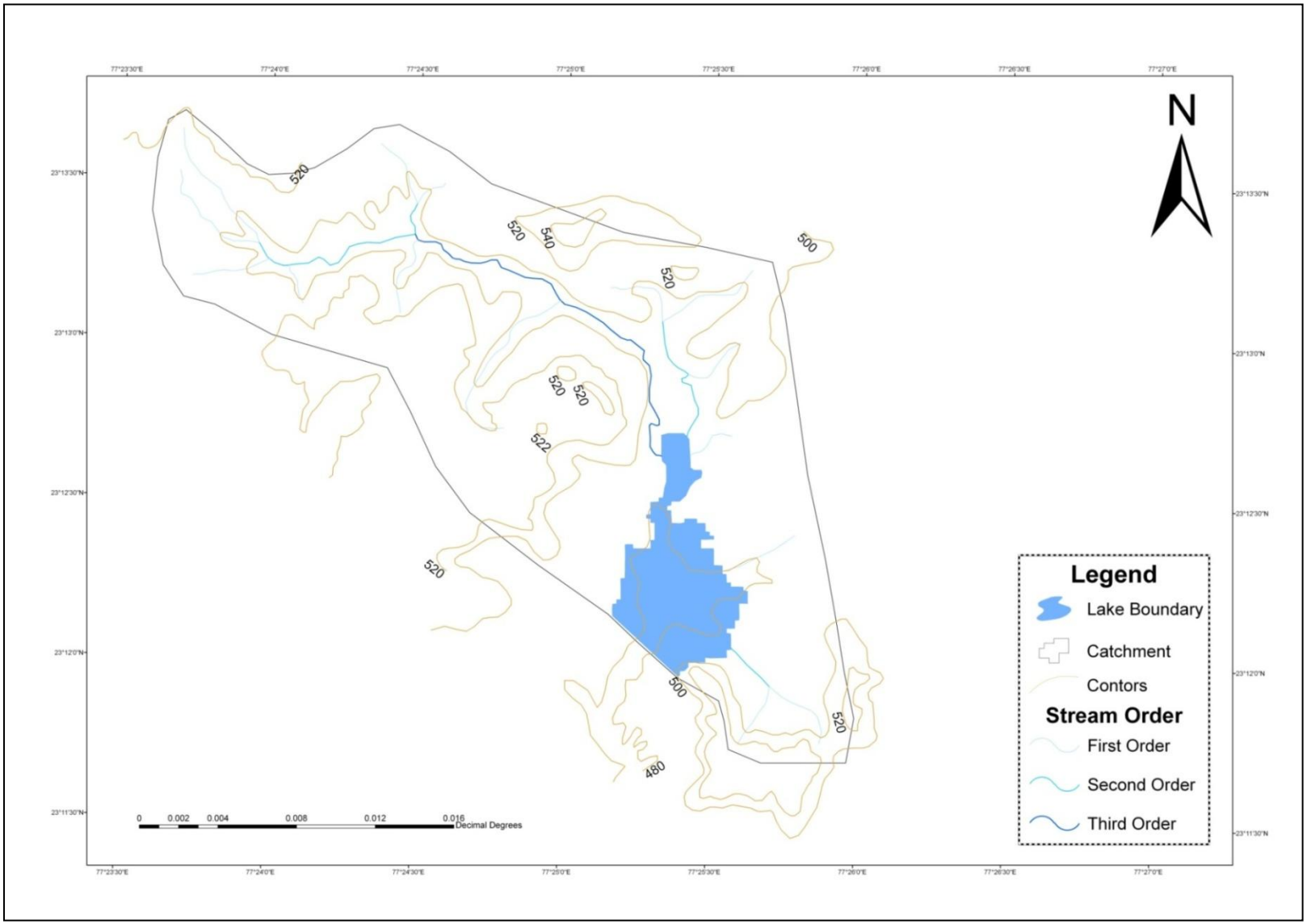


Table 3: Sampling site locations at surface water, ground water and peizometer in Shahpura basin.

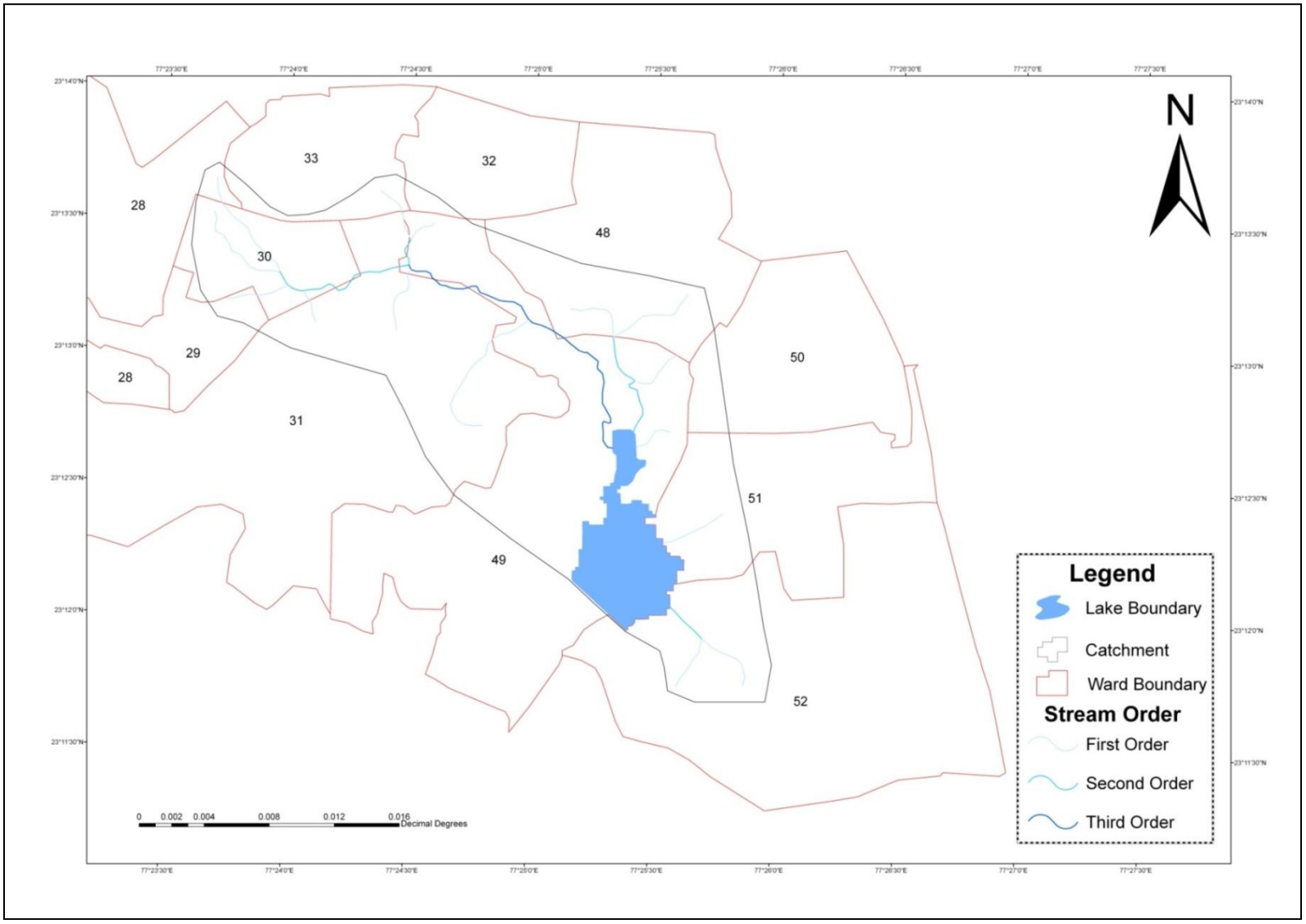
Code	Surface water source	Latitude (N)	Longitude (E)	code	Ground water Source	Latitude (N)	Longitude (E)	Code	Peizometers station	Latitude (N)	Longitude (E)
S-1	Main untreated source kotra Nullah	23°13'2.9"	77°25'6.6"					**PZ 01 A**	**Near PHE Office**	**23°12'55.1"**	**77°25'6.5"**
				GW-1	Tube well of BSNL Extension	**23**°12'52.6"	**77°25'10.3"**	**PZ 01 B**	Near Sampada Sanchanalaya	**23**°13'0.3"	**77°25'23.6"**
S-2	joining of two Nullah from char imli residential area behind PCB	23°13'31.4"	77°25'19.3"	**GW-2**	Tube well of NCHSE	**23**°12'50.7"	**77°25'34.4"**	**PZ02**	NCHSE	**23**°12'50.7"	**77°25'34.4"**
S-3	Dhobi Ghat Behind PCB	23°12'30.5"	77°25'18.1"	**GW-3**	Tube well hand pump 1100 Qtrs	**23**°12'40.6"	**77°25'35.1"**	**PZ03**	In front of Administrative Academy away from Dug well	**23**°12'28.7"	**77°25'26.9"**
S-4	In front of Administrative academy T Shape Point	23°13'21.38"	77°25'27.07"	**GW-4**	Dug well Academy Building	**23**°12'28.5"	**77°25'28.9"**	**PZ04**	In front of Administrative Academy near from Dug well	**23**°12'29.5"	**77°25'28.4"**
S-5	near Shahpura Park (Recreation centre)	23°13'31.6"	77°25'9.28"	**GW-5**	Tube well Rain bow Treat	**23**°12'11.3"	**77°25'33.1"**				
S-6	Inflow of sewage water from residential area of shahpura	23°13'5.07"	77°25'31.59"								
S-7	Waste weir			**GW-7A**	Dug well Seepage water waste weir	**23**°12'2.1"	**77°25'15.3"**				
		23°13'2.3"	77°25'17.5"	**GW-7B**	Tube Well C-Sector Shahpura	**23**°12'56.7"	**77°25'12.9"**				
S-8	Central part of the lake	23°13'13.81"	77°25'19.56"								
S-9	Behind C I villa residential			**GW-9**	Tube well Kashish	**23**°12'26.1"	**77°25'6.5"**	**PZ 09A**	Amrapali enclave A	**23**°12'29.4"	**77°25'13.1"**

	colony				Restaurent at the road Side						
		23°12'26"	77°25'10.7"					**PZ 09B**	Amrapali Enclave B	**23°**12'27.1"	**77°25'12.9"**
S-10	near Palm tree			**GW-10**	Tube well Avtaar Singh Bedi	**23°**12'21"	**77°25'4.1"**	**PZ 10 A**	In Avtaar Singh Bedi campus	**23°**12'21.4"	**77°25'5.2"**
		23°12'15.32"	77°25'9.56"					**PZ 10B**	In Ram mandir away from Avtaar singh bedi and across the road	**23°**12'18.4"	**77°24'55.6"**
S-11	Starting Point of earthen dam			**GW-11A**	Dug well Jugal Kishore	**23°**12'13.7"	**77°24'59.4"**				
				GW-11B	Tube Well jugal kishore	**23°**12'13.7"	**77°24'59.5"**				
		23°13'11.34"	77°25'6.87"	**GW-11C**	Tube well Shri N R Khare	**23°**12'5.7"	**77°24'59"**				
S-12	Middle Point of earthen dam			**GW-12-A**	Tube Well Dr Dubey	**23°**12'7.4"	**77°25'3.4"**	**PZ 12**	Naveen higher secondary School	**23°**12'5.7"	**77°25'7.1"**
				GW -12 B	Tube Well Shri Lobo	**23°**12'4.6"	**77°25'1.6"**				
		23°13'6.9"	77°25'12.01"	**GW-12 C**	Tube Well Dr M.k. Khanna	**23°**11'59.3"	**77°24'57.5"**				
S-13	Nullah Behind new friends Colony(out flow of waste weir)	23°12'0.8"	77°25'13.1"	**GW-13**	Tube well H.No. 5 Mr Murlichandani	**23°**11'52.4"	**77°25'3.8"**				

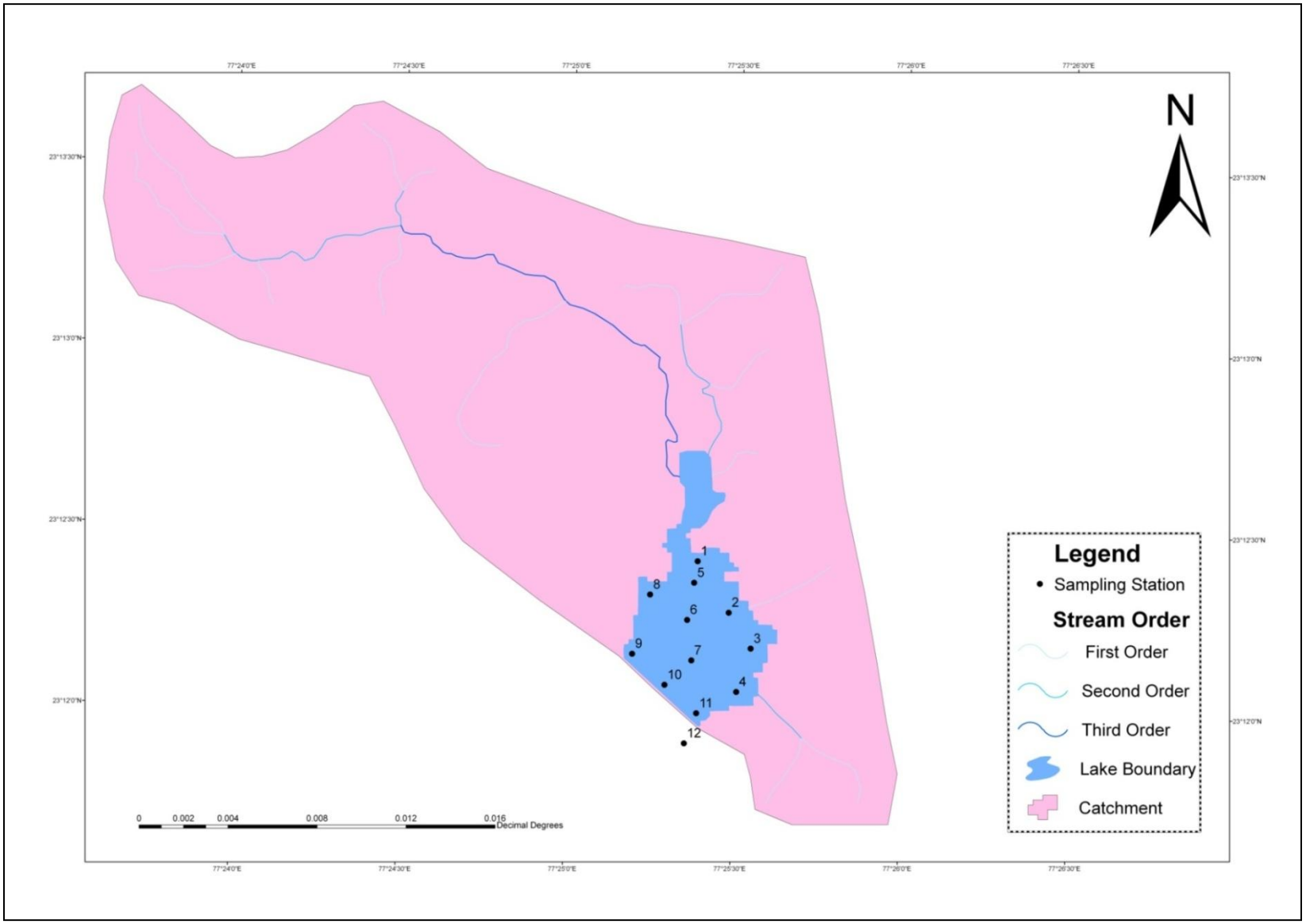
Map 4: Contour map of Shahpura lake basin



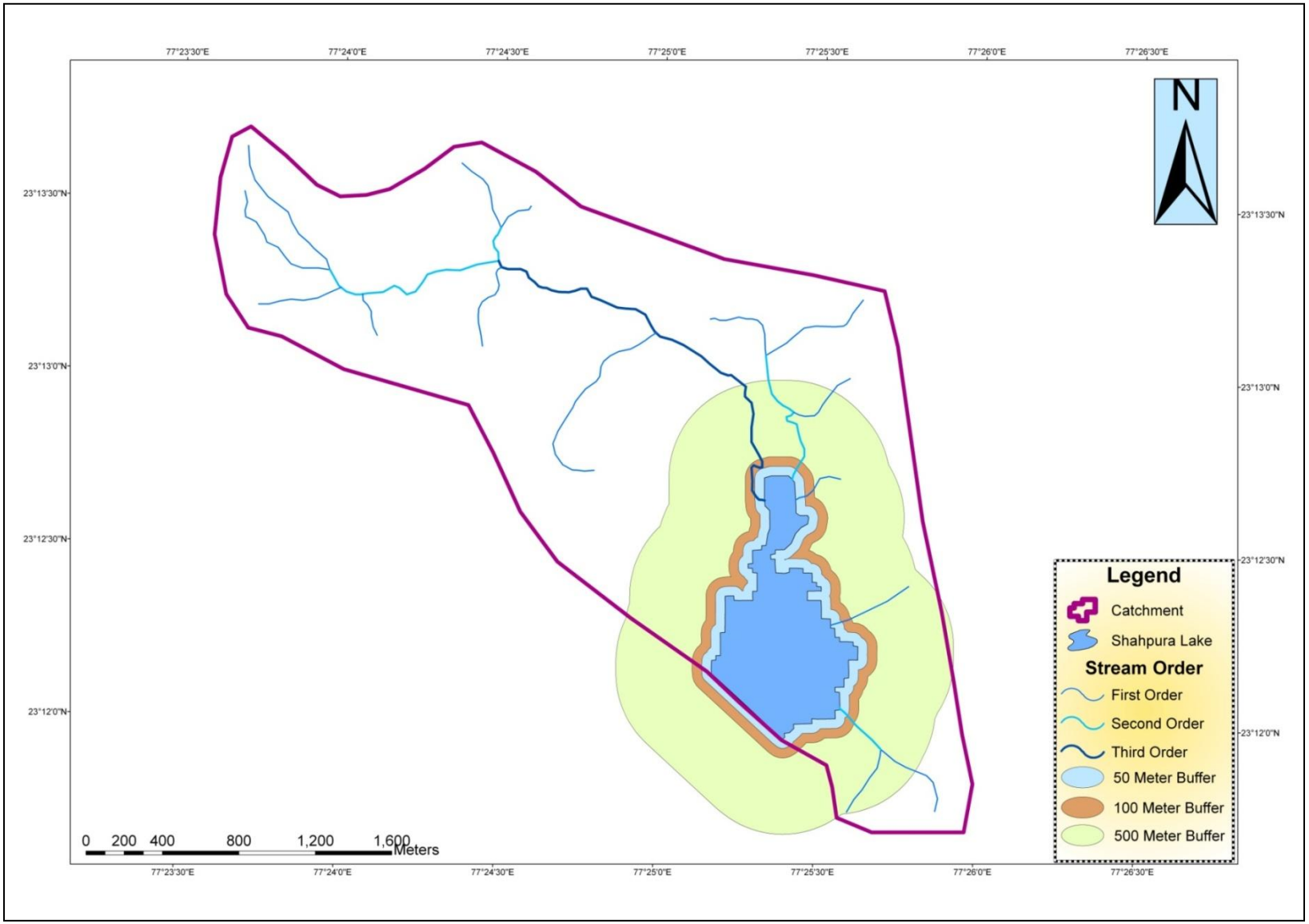
Map 5: Ward map of Shahpura lake basin



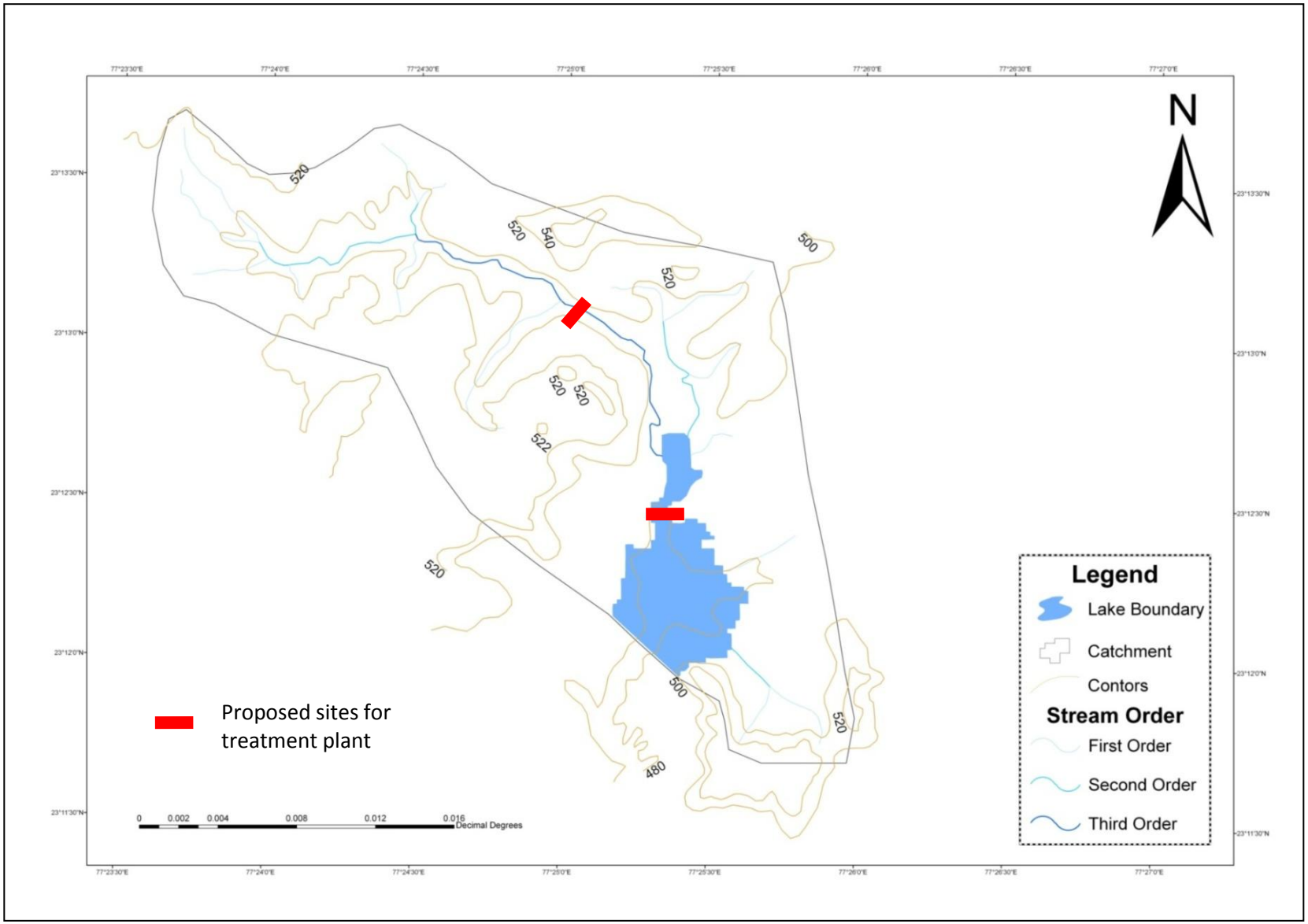
Map 6: Drainage map of Shahpura lake



Map 7: Buffer map of Shahpura lake



Map 8: Location map of constructed wetland on point source of Shahpura lake



3. Methodology:

3.1 Water quality parameters: Standard methods (APHA, 1998; Trivedy *et al.*, 1998) and Standard analytical Procedure for water analysis (Draft version 1.0, August 1998) were followed for the physical and chemical analysis of both surface and ground water. Temperature was measured using mercury-filled centigrade thermometer. pH was measured on the site using pen type pH meter. Winkler's modified method (APHA, 1998) was used to estimate oxygen concentration. In the laboratory, the samples were treated with concentrated sulphuric acid to liberate the iodine equivalent to dissolved oxygen originally present. Exactly 100 ml of the sample was titrated against standard sodium thiosulphate solution of known normality (0.025N) using starch as indicator. The values were expressed in mg/l.

Most important pollution indicator parameters supporting the PDS objectives such as Nutrients (Nitrite-nitrate, phosphate), and Organic matter (COD) were estimated using UV spectrophotometry, Ascorbic acid spectrophotometry and Open air reflux method respectively.

Other general and mostly anthropogenic parameters such as Chloride was estimated by Argentometric titration method, Total hardness, calcium and magnesium determined using complex metrically by EDTA method and Sodium and potassium were determined by flame photometric method using Digital flame photometer model 381 E.

3.2 Sediment analysis:

The sediment samples were collected with the help of Ekman grab and Peterson grab mud sampler in polythin bottles for analysis. The sediment quality analysis was done using Adoni (1985) and Trivedy *et al.*, (1998).

3.3 Phytoplankton and Zooplanktons:

Qualitative: The samples were collected by filtering 50 liters of water through plankton net (Mesh size No. 20). Plankton (phyto and zoo) samples were preserved in 100 ml plastic bottle by using Lugol's Iodine solution as preservative (Adoni,*et al* ., 1985). After preservation the qualitative analysis was done by placing a drop of concentrated sample on glass slide and covered with a cover slip. The glass slide with sample was placed under compound microscope and focuses one edge of the glass cover. Biological organisms were identified upto species level wherever possible.

Quantitative:

Plankton (phyto and zoo) samples were preserved in 100 ml plastic bottle by using Lugol's Iodine solution as preservative (Adoni, 1985). Preserved samples were identified by Drop Count Method Phytoplankton abundance was calculated by this formula (Adoni 1985).

Organisms $\mathbf{L^{-1} = A * 1/l * n/v}$
Where A = number of organism per drop
v = volume of one drop (ml)
n = total volume of concentration sample (ml)
L = volume of original sample (l).

3.4 Benthos:

The Benthos sample were collected with the help of Peterson grab, mud sampler and then, the collected samples were sieved through 2 mm and 0.5 mm mesh size sieve one after the other (Adoni 1985). The material which retained on sieve were sorted out with the help of forcep and brush and were collected in narrow mouthed plastic bottle containing 70% alcohol as preservative, some attached fauna from stones and Macrophytes were also collected. Identification of all macrofaunal organisms were completed with the help of metzer binocular light microscope and the species were identified using following keys and manuals,

- Fresh water molluscs of India-Subba Rao, (1989).
- Fresh water biology-Needham and Needham (1962)
- Work book on Limnology-Adoni, (1985).

3.5 Macrophytes:

Plants were collected in the polythene bags. Tight packing was avoided to minimize the heating and to prevent the respiration and other losses. For identification of plant species, 2 or 3 specimen of each species were collected. Identification of macrophytes were completed by using following keys and manuals like water plants of the world by C.D. Cook *et al.* (1974), Marsh plant of India and Burma by Biswas and Calder (1984), Adoni (1985).

3.6 Fish biodiversity:

Fishes were collected from the landing sites and identified as per the standard keys of Quereshi and Quereshi (1983), K. C Jayram (1999) and Gopalji Shrivastava (1998).

3.7 Statistical analysis of physicochemical and biological data

3.7.1 Prati indexing: Component of Prati index for water quality assessment. This index is based on 6 parameters namely $\%O_2$, BOD, COD, NH_3, NO_3 and PO_4 and rates the water quality from class 1 (unpolluted) up to class 5 (heavily polluted). It is used to classify the water body as given bellow

Class	Color-code	Sum of points	Quality
1	Blue	3 – 4.5	Very good, unpolluted
2	Green	4.6 – 7.5	good, slightly polluted
3	Yellow	7.6 – 10.5	moderate, doubtful
4	Orange	10.6 – 13.5	bed, polluted
5	Red	13.6 – 15	very bed, very polluted

3.7.2 Carlson's trophic state index: It is used to classify the water body as given bellow. The index ranges from 0-100 and has the advantage over the use of raw variables.

Carlson's Trophic Classification of Lake.					
TSI	**Chl**	**P**	**SD**	**Trophic Class**	**Status**
<30-40	0-2.6	0-12	>8-4	Oligotrophic	Good
40-50	2.6-20	12-24	4-2	Mesotrophic	Moderate
50-70	20-56	24-96	2-0.5	Eutrophic	Poor
70-100+	56-155+	96-384+	0.5-<0.25	Hypereutrophic	Critical
Chl- chlorophyll, P- Total phosphorous, SD- Secchi depth (Meters)					

3.7.3 Biomonitoring indices using macrozoobenthos: In BMWP scoring they will give certain score according to their sensitivity to pollution and finally the status of the water body will be classified as Clean, Slightly polluted, Moderately polluted, Heavily polluted and Severely polluted.

BMWP scoring table			
S. No	**BMWP Score**	**Water quality class**	**Water quality characteristics**
1.	7 and more	A	Clean
2.	6-7	B	Slight pollution
3.	3-6	C	Moderate pollution
4.	2-5	D	Heavy pollution

5.	0-2	E	Severe pollution

3.7.4 Nygaard's algal index for algal trophic status: Nygard (1949) proposed five indices to evaluate the organic pollution of a water body on the basis of algal groups (Myxophycean index, Chlorophycean index, Diatom index, Euglenophycean index and compound index). These indices have been developed on the basis of the fact that various algal groups have different tolerance to organic pollution and nutrient enrichment.

Calculation of Nygard index		
Index	**Oligotrophic**	**Eutrophic**
Myxophycean	0.0-0.4	0.1-3.0
Chlorophycean	0.0-0.7	0.2-9.0
Diatom	0.0-0.3	0.0-1.75
Euglenophycean	0.0-0.2	0.0-1.0
Compound	0.0-0.1	1.2-2.5

4. Water quality of Shahpura lake

A. Chemical observation

4.1 Water quality observation of Shahpura Lake during November 2011 to October 2012:

Air temperature: The air temperature value ranged between 19-37^{0}C.The Maximum air temperature value of 37^{0}C was recorded at Site-12, and While as Minimum value of 19^{0}C was recorded at Site-12. The highest value of 37^{0}C was recorded in July and lowest value of 19^{0}C was recorded in January at Shahpura Lake (Fig-1).

Water temperature: The Water temperature ranged between 16 to 29^{0}C. The Maximum water temperature value of 29^{0}C was recorded at Site-2, and Minimum value of 16^{0}C was recorded at Site-10. The highest value of 29^{0}C was recorded in April and lowest value of 16^{0}C was recorded in February the Shahpura Lake 2012 (Fg-2).

Conductivity: Since the ions are the carries of electricity, the electrical conductivity of the water raises according to the content of soluble salts in the water. The value ranged between 467 to 958 µs/cm. The highest value of 958 was recorded in May and lowest value of 467 was recorded in September in the ShahpuraLake. The Maximum value of 958 was recorded at Site-2 and Minimum value of 467 was recorded at Site -11 (Fig 3).

Total dissolved solids (TDS): Total dissolved solids are mainly the inorganic minerals and sometimes some organic matter. The TDS value ranged between 215 to 631 mg/l. the highest value of 631 mg/l was recorded May month and lowest value of 215 mg/l was recorded at September in this Lake. The Maximum value of 631mg/l TDS was recorded at Site-2 and while Minimum value of 215 mg/l was recorded at Site-11 in the Shahpura Lake 2012 (Fig 4).

pH: pH is the logarithm of the reciprocal of the hydrogen ion concentration in moles per liter. There was significant change in the pH. The pH value ranged between 6.3 to 8.8. The highest value of 8.8 was recorded in April and September and lowest value of 6.3 was recorded in December. The Maximum values 8.8 were recorded at Site-6 and 11 and while as the Minimum values 6.3 of was recorded at Site-9 (Fig 5).

Depth: The depth value ranged between 0.3 to 5.5 m. During the entire study period the Maximum depth 5.5 m was recorded at Site-6, and Minimum depth 0.3 feet was recorded at Site-12. The highest value of 5.5 m was recorded in September, and lowest value of 0.3 m was recorded in July (Fig. 6).

Secchi transparency: The Secchi transparency value ranged between 18.25 to 51.5 cm. The highest value of 51 cm was recorded in November and lowest value of 18.15 cm was recorded in December in this Lake. The Maximum value of 51.5 cm Secchi transparency was recorded at Site-3, and Minimum value of 18.25 cm was recorded at Site-10 at Shahpura Lake (Fig 7).

Turbidity (NTU): The turbidity value ranged between 2 to 96 NTU. The minimum turbidity of 2 NTU was recorded on September at site 11 and while the maximum turbidity was recorded 96 NTU in March at site 1. (Fig -8).

Dissolved oxygen: The D.O. value ranged between 1.6 to 13.2 mg/l. The highest value of 13.2 mg/l was recorded in January and lowest value of 1.6 mg/l was recorded in February month. The Maximum dissolved oxygen (D.O.) value of 13.2 mg/l was recorded at Site-12. While as Minimum value of 1.6 was recorded at Site-1 in the Shahpura Lake (Fig 9).

Alkalinity: The Carbonate alkalinity value ranged between 0 to 160 mg/l. the highest value of 160 mg/l noted in July month and lowest value of 0 mg/l was noted in February month at all sites of Shahpura lake. The maximum value of carbonate alkalinity 160 mg/l was recorded at Site-3 (Fig.10)

The Bicarbonate alkalinity value ranged between 16 to 308 mg/l. The highest value of 308 mg/l was noted in March and July and lowest value of 16 mg/l was noted in January. The Maximum value of 308 mg/l was recorded at Site-1, site-4 and minimum value of 16 mg/l was recorded at Site -2 in Shahpura Lake (Fig 11).

Total Hardness: The Total Hardness value ranged between 148 to 348 mg/l. During the study period the highest value of 348 mg/l was noted in May month and lowest value of 148 mg/l was noted in September. The maximum value of total hardness 348 mg/l was recorded at Site-4 and while as minimum value of 148 mg/l was recorded at Site-10 in this Lake (Fig 12).

Calcium Hardness: The Calcium Hardness value ranged between 37.61 to 78.4mg/l. The highest value of 205m/l was noted in monsoon season and lowest value of 174mg/l was noted in summer season. The maximum value of 212.8 mg/l was recorded at site-10 and minimum value of 172.51 mg/l was recorded at site-5 in the Shahpura Lake 2012.

Magnesium Hardness: The Magnesium Hardness value ranged between 37.61 to 78.4mg/l. The highest value of 75mg/l was recorded in Monsoon season and lowest value of 40mg/l was recorded in Summer season. The Maximum value of 78.4 mg/l was recorded at Site-4 and Minimum value of 37.61 mg/l was recorded at Site-10 in this Lake 2012.

Chloride: The chloride value ranged between 32 to 135 mg/l. The highest value of 135 mg/l was noted in May month at site 4 and site -5 and lowest value of 32 mg/l was noted in September at site-2 (Fig 13).

Biological Oxygen Demand (BOD): In present study BOD recorded between 3.2 to 19.2 mg/l. the highest value of BOD 19.2 mg/l recorded in December month and lowest value of 3.2 mg/l recorded in November and October month .In spatial case maximum BOD value 19.2 mg/l was recorded in Site -1 and minimum value of 3.2 mg/l was recorded in Site-1 and Site 11 (Fig 14).

Chemical Oxygen Demand (COD): In present study COD recorded between 6.96 to 105.95 mg/l. The highest COD value 105.95 mg/l recorded in July month and lowest value of 6.96 mg//l recorded in September .In spatial case maximum COD value of 105.95 mg/l was recorded at Site-4 and minimum value of 6.96 mg/l recorded in Site-1 (Fig 15).

Nitrate: In present study Nitrate value ranged between 3.01 to 23.05 mg/l. The highest value of 23.05 mg/l was noted in January and lowest value of 3.01 mg/l was noted in September. During the present study period the Maximum value of 23.05 mg/l was recorded at Site-3 and Minimum value of 3.01 mg/l was recorded at Site-9 (Fig 16).

Ammoniacal Nitrogen: The minimum ammonical nitrogen of 0 mg/l was recorded on November and September at site 2, site 4, site 9, site 10 and site 12 while the maximum ammonical nitrogen recorded was 2.97 mg/l on January month at site 1. (Fig -17).

Phosphate: The Phosphate value ranged between 0 to 4.43 mg/l. During the present study period the highest value of 4.43 mg/l was recorded in May and lowest value of 0 mg/l was recorded in September. The Maximum value of 4.43 mg/l was recorded at Site-7 and Minimum value of 0 mg/l was recorded at Site-3 and 5 (Fig 18).

Fig 1: Graphical presentation of air temperature in Shahpura lake

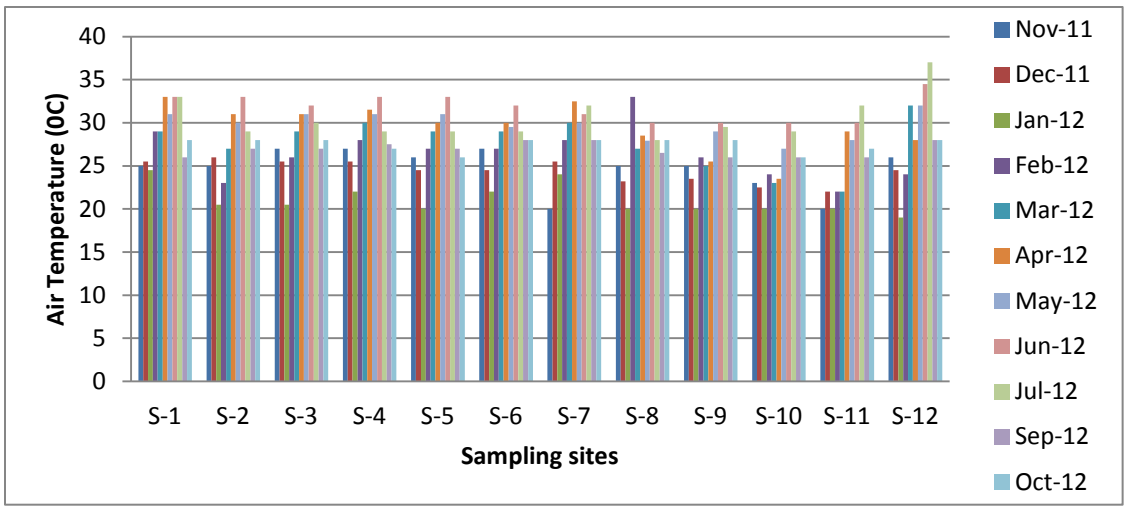


Fig 2: Graphical presentation of water temperature in Shahpura lake

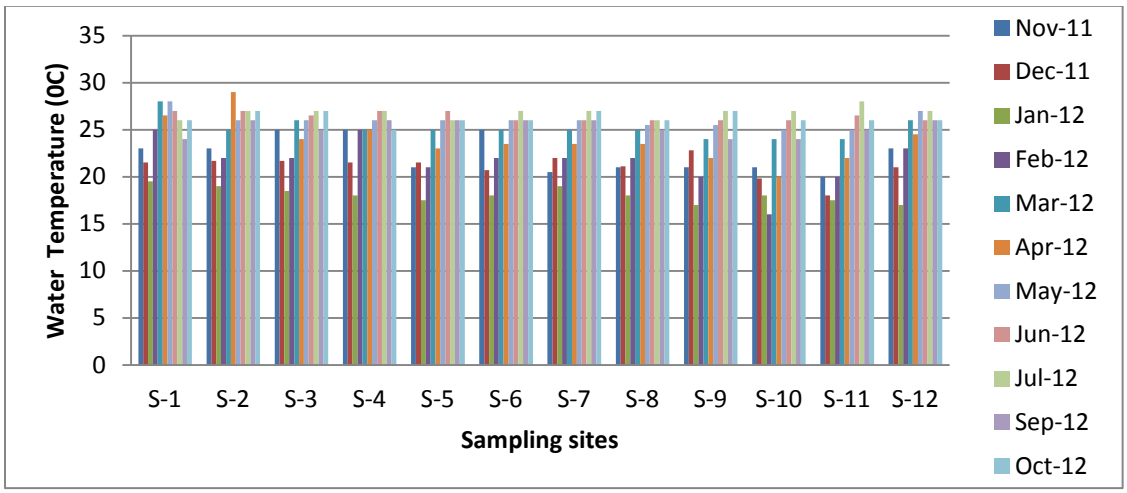


Fig 3: Graphical presentation of conductivity in Shahpura lake

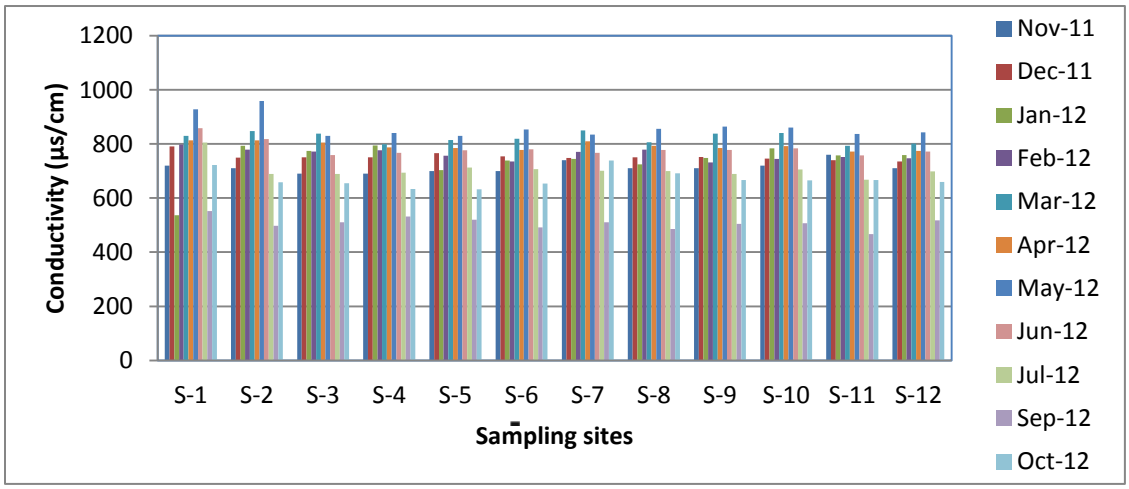


Fig 4: Graphical presentation of Total Dissolved Solids (TDS) in Shahpura lake Bhopal.

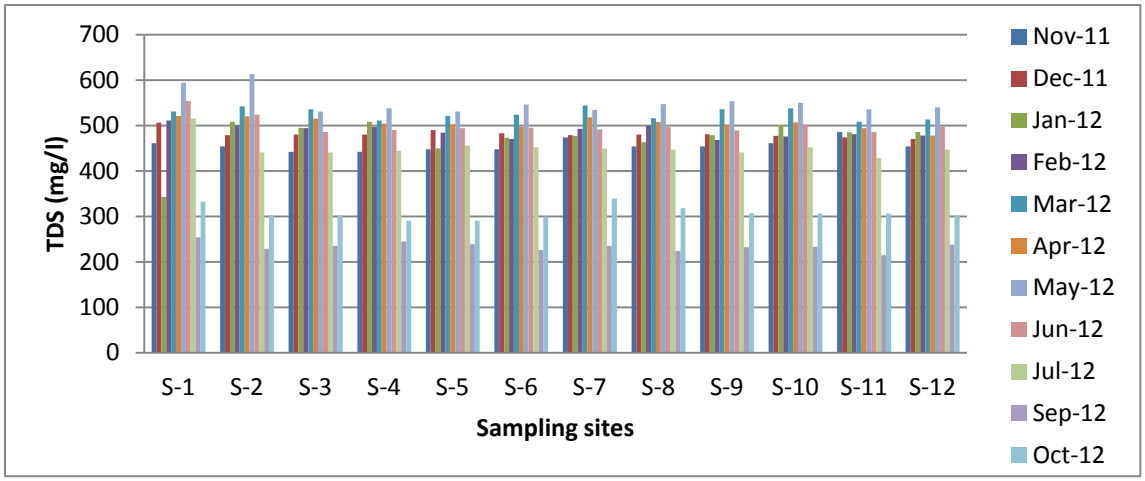


Fig 5: Graphical presentation of pH in Shahpura lake Bhopal.

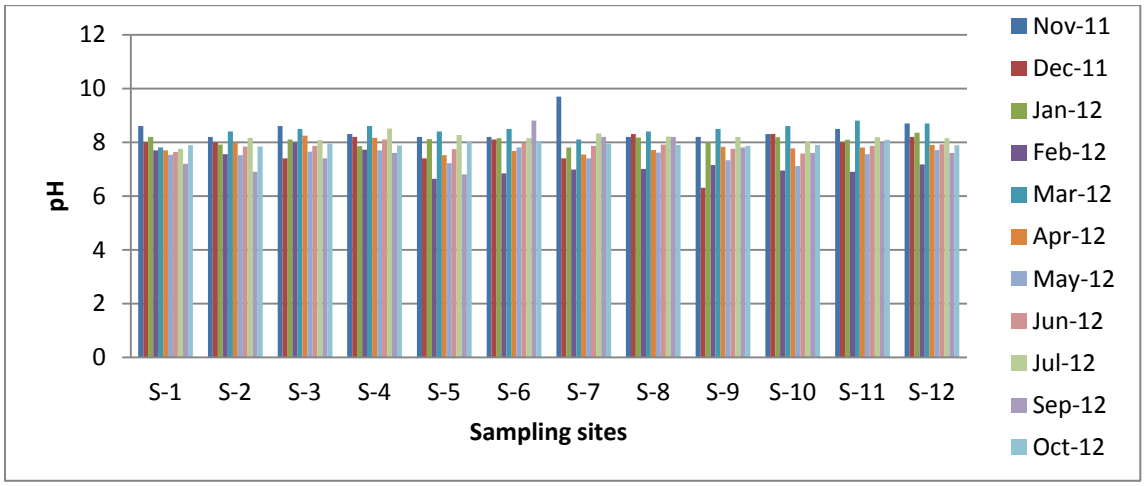


Fig 6: Graphical presentation of depth in Shahpura lake Bhopal.

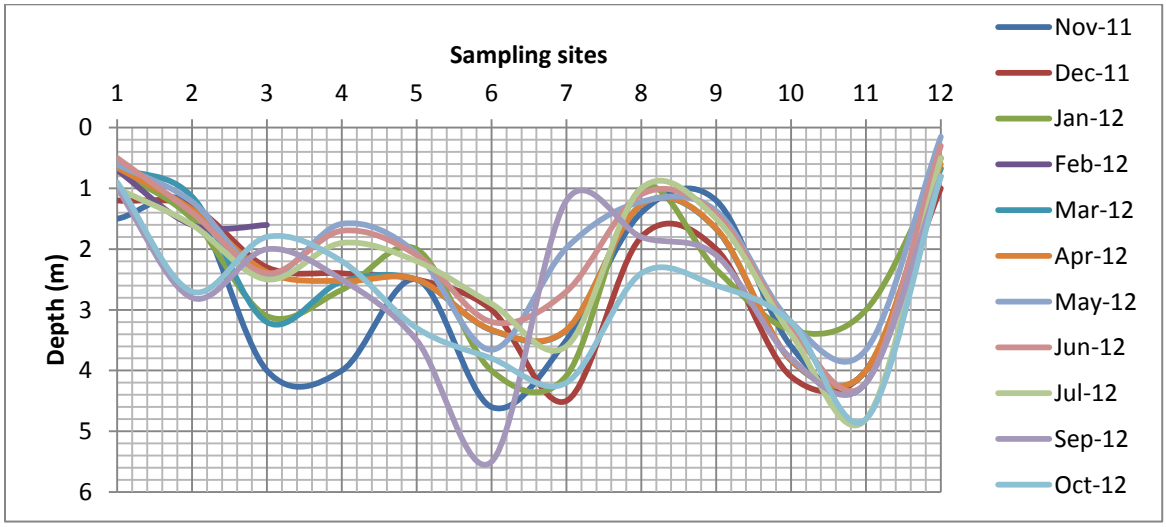


Fig 7: Graphical presentation of secchi transparency in Shahpura lake Bhopal.

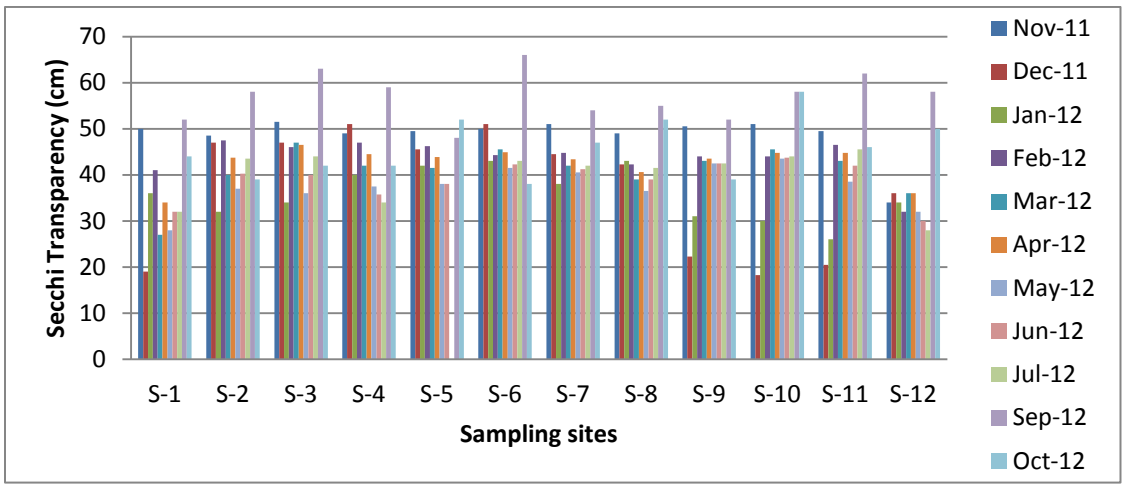


Fig 8: Graphical presentation of turbidity in Shahpura lake Bhopal.

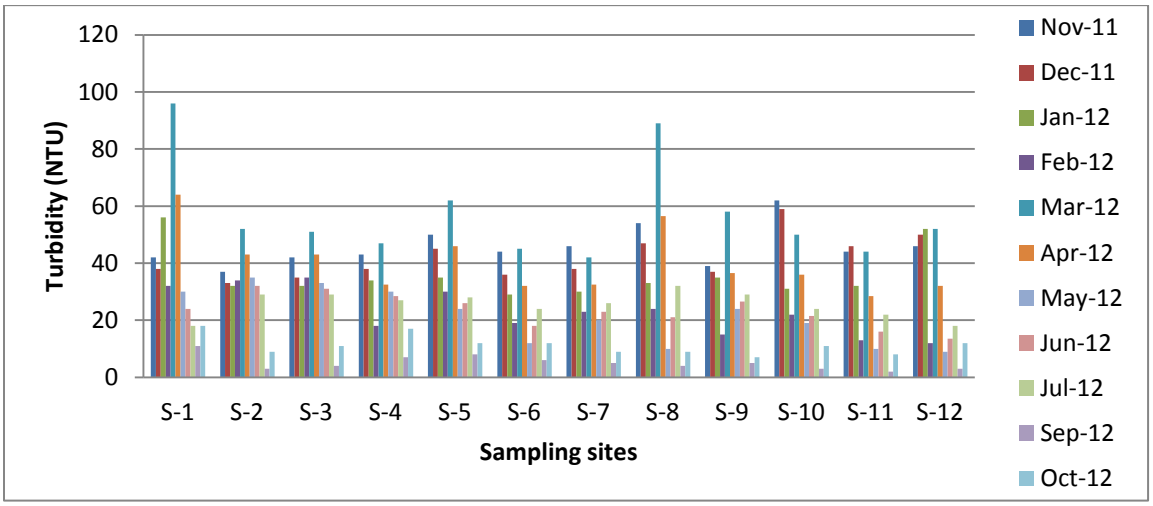


Fig 9: Graphical presentation of dissolved oxygen (DO) in Shahpura lake Bhopal.

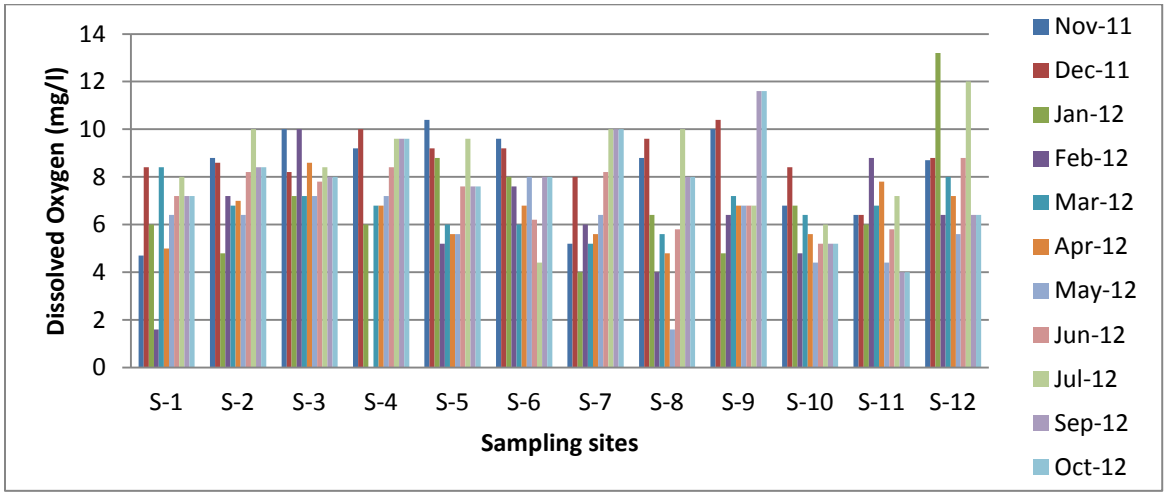


Fig 10: Graphical presentation of carbonate alkalinity in Shahpura lake Bhopal.

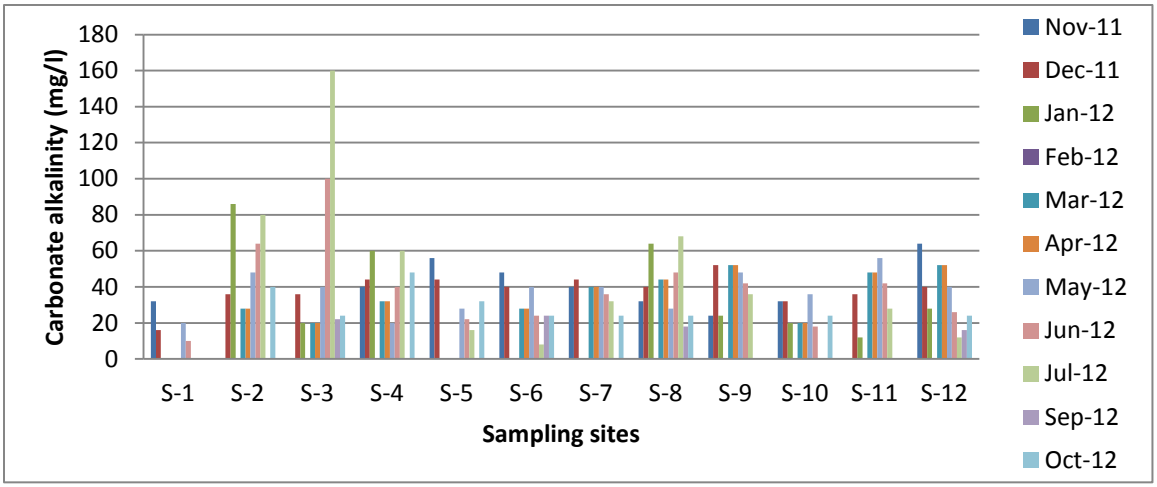


Fig 11: Graphical presentation of bicarbonate alkalinity in Shahpura lake Bhopal.

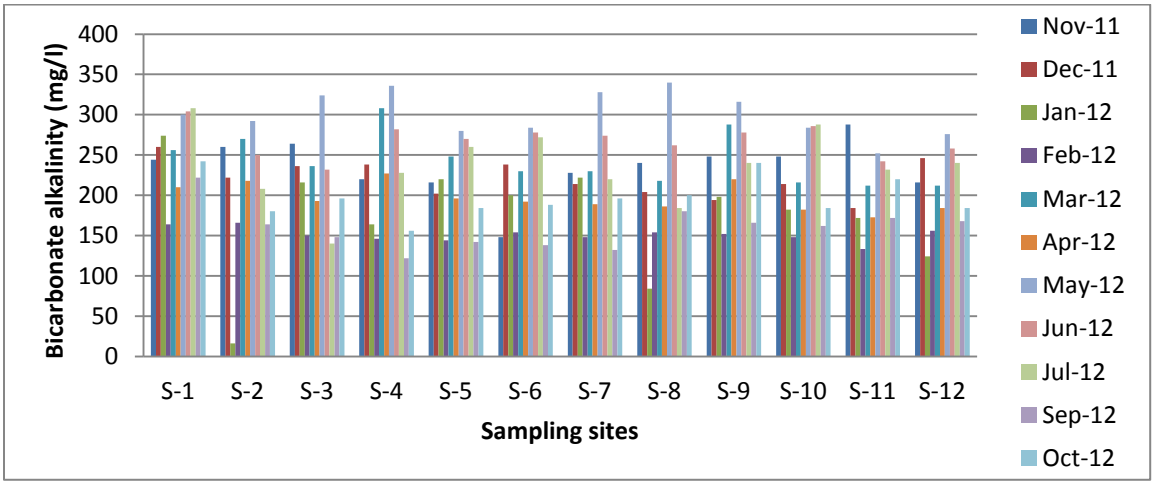


Fig 12: Graphical presentation of total hardness in Shahpura lake Bhopal.

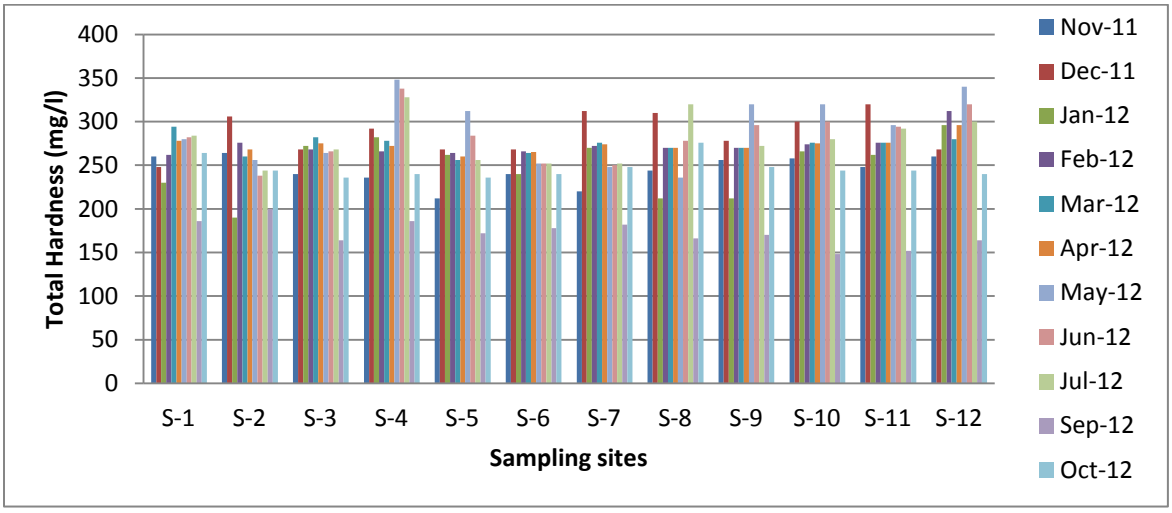


Fig 13: Graphical presentation of chlorides in Shahpura lake Bhopal.

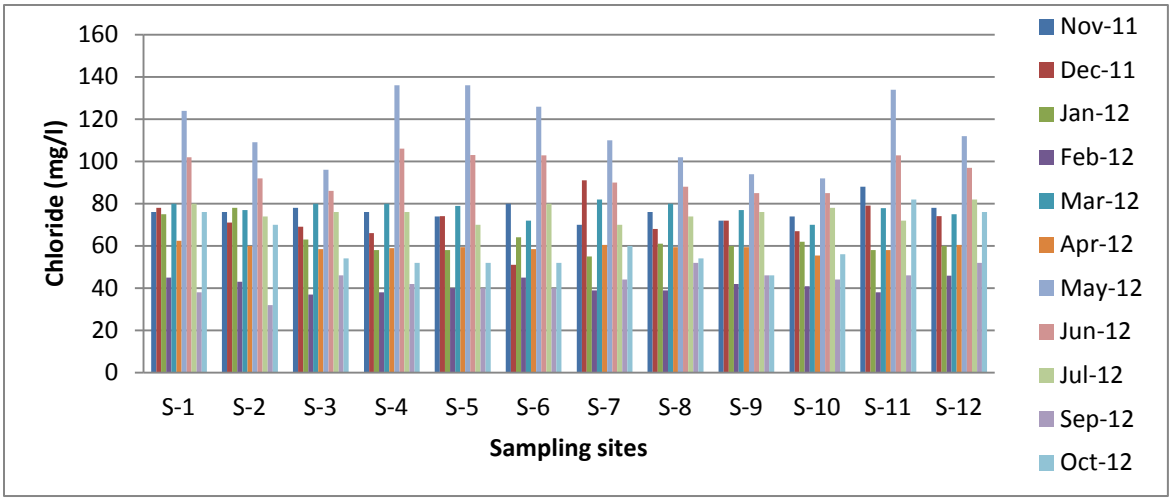


Fig 14: Graphical presentation of biochemical oxygen demand in Shahpura lake Bhopal.

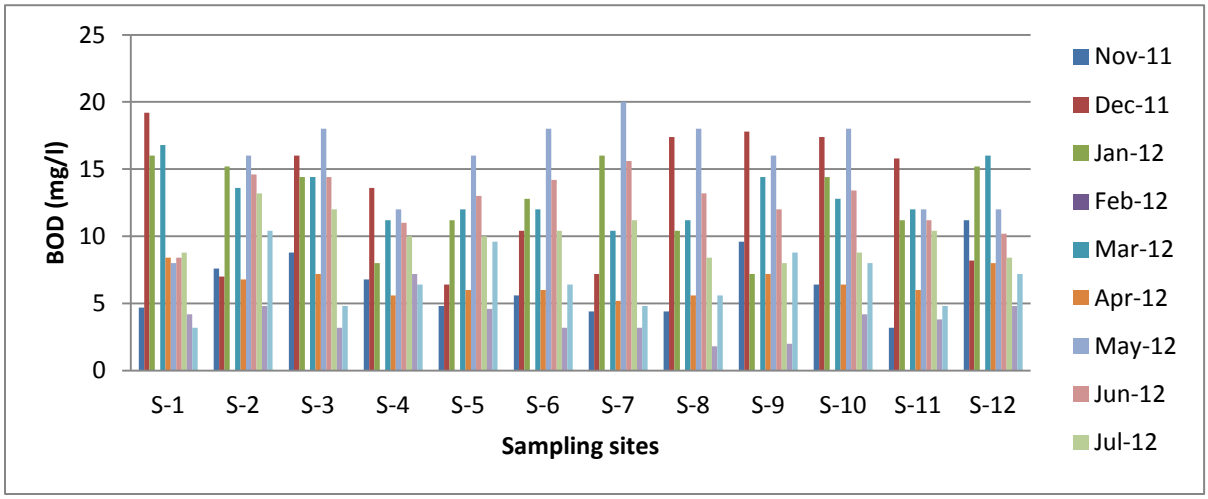


Fig 15: Graphical presentation of chemical oxygen demand in Shahpura lake Bhopal.

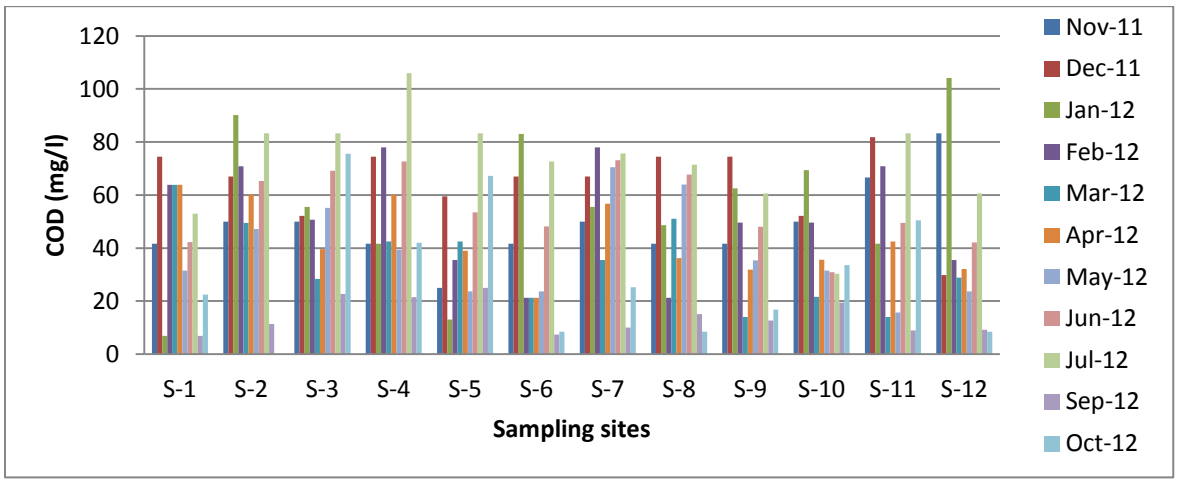


Fig 16: Graphical presentation of nitrate nitrogen in Shahpura lake Bhopal.

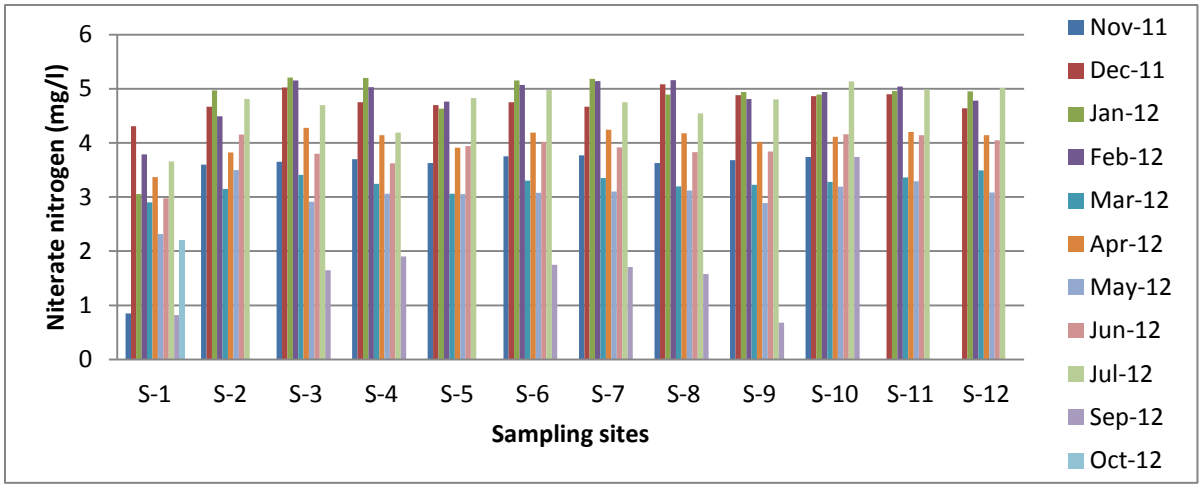


Fig 17: Graphical presentation of ammonical nitrogen in Shahpura lake Bhopal.

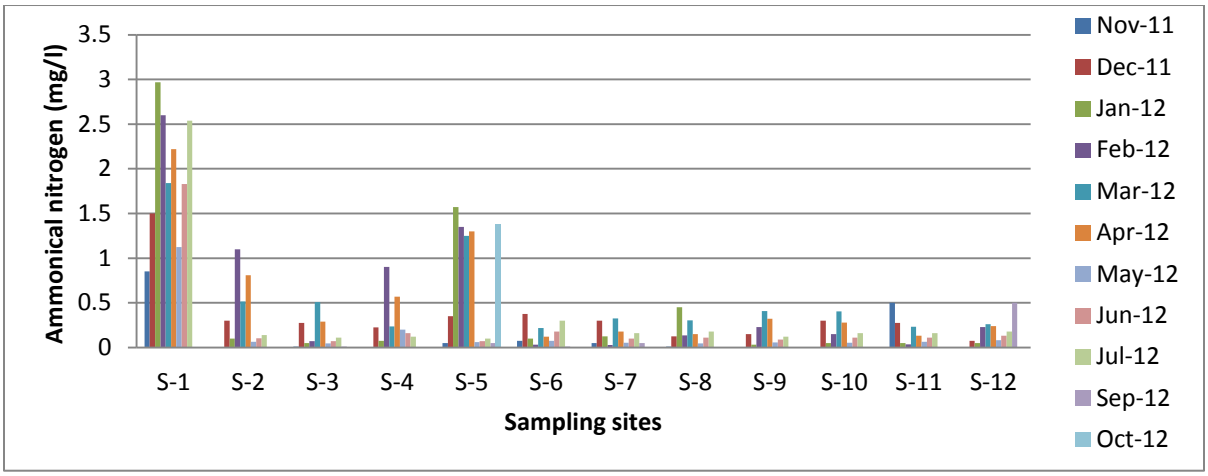


Fig 18: Graphical presentation of phosphate in Shahpura lake Bhopal.

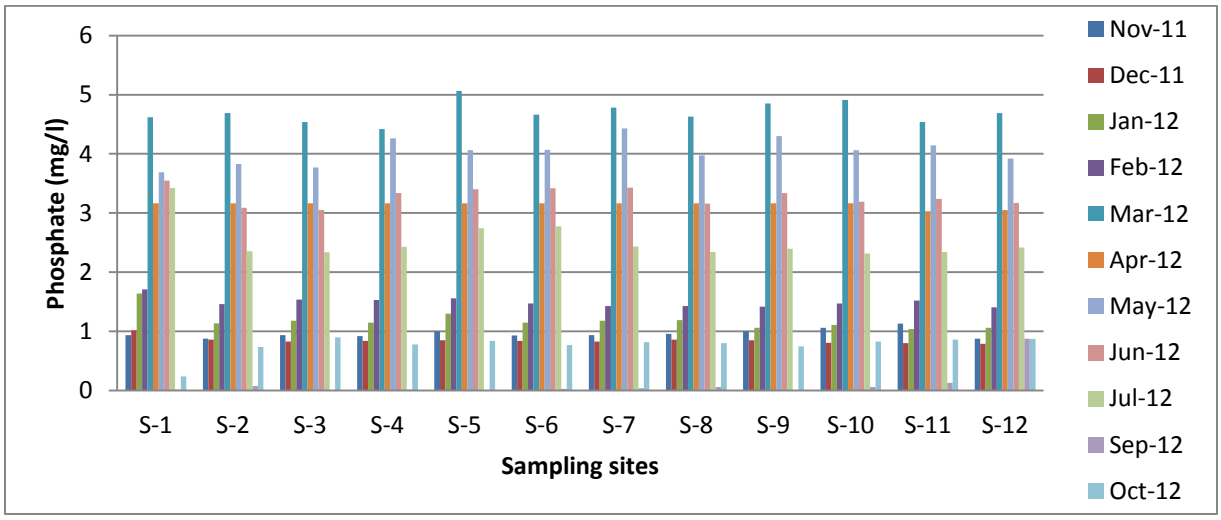


Table 4: Water quality of Shahpura lake during November 2011 to October 2012

Parameters		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20	21
S-1	Min	24.5	19.5	536	254	7.2	0.5	19	11	1.6	10	7.2	230	130	17.5	44.955	3.2	6.944	0.85	0.85	0.24	0.04	0.02
	Max	33	28	928	594	8.6	1.5	52	96	8.7	82.8	308	294	231	186	132	54	74.4	4.31	6.94	4.62	0.525	1.01
	Avg.	28.45	25	759.2	466	7.82	0.858	35.91	39	6.5	14.6	234	244	186.5	69.9	84.56	13.41	45.59	3.062	2.44	2.26	0.193	0.45
	SD	3.02	2.72	121	107	0.364	0.3	10.05	25	2.1	25.1	86.4	82.9	31.84	45.4	25.466	14.7	20.48	1.002	1.72	1.47	0.21	0.36
S-2	Min	20.5	19	498	229	6.9	1.133	32	3	4.8	28	8.4	238	126	16.5	42.957	6.8	32	3.15	0.06	0.74	0.2	0.08
	Max	33	29	958	613	8.4	2.8	58	52	10	100	292	306	228	200	164	36	90.2	4.967	11.3	4.69	0.625	0.47
	Avg.	27.22	24.8	755.6	465	7.846	1.622	43.32	31	7.7	46.4	190	231	187.4	73.2	83.062	12.76	61.54	4.196	1.44	2.01	0.27	0.31
	SD	3.58	2.99	118.7	110	0.407	0.568	6.934	14	1.4	33.2	95.6	81.9	31.01	62.5	31.555	9.08	17.58	0.643	3.49	1.49	0.227	0.17
S-3	Min	20.5	18.5	510	235	7.4	1.567	34	4	7.2	20	8	22	126	17.5	36.963	4.8	28.35	2.914	0.01	0.83	0.01	0.24
	Max	32	27	838	536	8.6	4	63	51	10	160	324	282	232	164	112	52	83.24	5.207	22.8	4.54	0.425	0.7
	Avg.	27.90	24.4	733.7	451	7.978	2.522	45.18	31	8.2	47.2	200	242	182.4	62.1	73.559	14.73	55.03	4.133	2.42	2.16	0.106	0.33
	SD	3.27	2.68	94.44	96	0.393	0.689	7.837	14	1	50.6	81.5	74.2	30.94	42.9	20.691	13.48	15.83	0.852	7.15	1.28	0.18	0.26
S-4	Min	22	18	532	245	7.6	1.584	34	7	6	20	9.6	236	104	18	37.962	5.6	39.36	3.058	0.2	0.78	0.6	0.02
	Max	33	27	840	538	8.6	4	59	47	10	119	336	348	256	186	135.93	54	106	7.2	21.4	4.42	0.6	0.46
	Avg.	28.31	24.6	733	450	8.056	2.402	43.8	29	8.2	49.5	210	262	180.8	83.2	79.875	12.6	58.22	4.413	2.39	2.23	0.133	0.25
	SD	3.07	2.63	89.2	95	0.334	0.674	7.363	12	1.4	27.3	90.2	94.3	43.75	52	31.957	14.24	21.95	1.217	6.7	1.35	0.263	0.16
S-5	Min	20	17.5	520	239	6.64	2	38	8	5.2	16	7.6	212	132	18	39.96	4.8	13	3.054	0.05	0.84	0.05	0.24
	Max	33	27	830	531	8.4	3.5	52	62	10	84.5	280	312	200	172	135.93	44	83.24	4.827	25	5.06	0.34	0.56
	Avg.	27.5	23.6	726.8	446	7.666	2.516	44.46	33	7.7	25.7	203	237	172.1	73.1	79.375	12.09	43.81	4.112	2.95	2.19	0.098	0.33
	SD	3.51	3.03	89.26	94	0.601	0.496	4.687	16	1.8	27.4	76.3	82.6	21.32	46.6	30.697	11.47	20.65	0.692	7.33	1.61	0.141	0.23
S-6	Min	22	18	492	226	6.84	2.9	38	6	4.4	8	8	24	138	19.4	44.955	6	8.4	3.08	0.03	0.77	0.01	0.03
	Max	32	27	853	546	8.8	5.5	66	45	9.6	95.3	284	268	224	178	132	46	83	5.15	7.38	4.66	0.25	1.22
	Avg.	27.81	24.1	728.1	447	8.022	3.74	46.31	25	7.5	30.5	199	233	187.7	54.1	78.466	12.89	40.74	4.149	0.89	2.26	0.113	0.42
	SD	2.72	2.79	96.13	97	0.497	0.797	7.489	13	1.5	26.7	79.1	70.1	23.06	44.9	29.923	12.03	24.54	0.805	2.28	1.39	0.091	0.47
S-7	Min	20	19	511	235	6.99	1.167	38	5	4	24	10	220	130	16	38.961	4.4	25.2	3.1	0.03	0.82	0.03	0.04
	Max	32.5	27	850	544	9.7	4.5	54	46	10	109	328	312	232	182	140	42	77.96	5.18	9.98	4.78	1.275	0.76
	Avg.	28.09	24	746.7	457	7.935	3.249	44.4	27	7.1	36.8	205	238	179.4	63.4	78.831	12.44	57.36	4.133	1.13	2.28	0.296	0.25
	SD	3.73	2.77	90.01	92	0.708	1.028	4.704	13	2.1	28.6	79.5	82.4	30.95	48.5	28.282	11.48	17.38	0.784	3.11	1.46	0.549	0.3

Parameters		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20	21
S-8	Min	20	18	486	224	7.01	1	36.5	4	1.6	24	8	18	130	18.5	38.961	4.4	8.4	1.8	0.01	0.8	0.01	0.06
	Max	33	26	855	547	8.4	2.4	55	89	10	88.9	340	320	205.8	166	120	46	74.4	5.16	15.1	4.63	0.25	0.53
	Avg.	27.00	23.6	733.6	450	7.966	1.43	43.65	35	6.7	43.7	189	246	179.2	74	74.65	12.75	48.79	3.943	1.66	2.18	0.088	0.3
	SD	3.43	2.68	96.24	96	0.402	0.449	5.828	25	2.6	24	87.7	81.5	23.13	49.2	22.74	12.31	20.92	1.055	4.73	1.34	0.104	0.19
S-9	Min	20	17	504	232	6.3	1.2	22.3	5	4.8	0	11.6	212	134	20.4	41.958	7.2	14	2	0.03	0.68	0.02	0.01
	Max	30	27	864	553	8.5	2.6	52	58	12	129	316	320	212	170	132	38	74.4	4.94	12.6	4.85	0.2	0.8
	Avg.	26.13	23.3	733.1	449	7.722	1.804	41.16	28	7.9	41.7	217	245	177.7	75.8	74.196	12.64	43.7	3.91	1.4	2.16	0.079	0.32
	SD	2.92	3.14	96.27	96	0.607	0.433	8.311	15	2.1	34.8	82.4	85.5	24.17	42.9	24.686	9.742	18.59	0.991	3.94	1.52	0.083	0.29
S-10	Min	20	16	507	233	6.95	3.2	18.25	3	4.4	18	5.2	244	150	12	40.959	6.4	21.6	3.193	0.05	0.81	0.05	0.06
	Max	30	27	860	550	8.6	4.1	58	62	9	57.8	288	320	308	148	120	28	69.44	5.136	19.4	4.91	0.425	1.18
	Avg.	24.90	22.4	740.5	455	7.85	3.563	43.7	31	6.2	23.6	203	254	202	58.5	72.833	12.15	40.78	4.252	2.09	2.43	0.13	0.48
	SD	2.9901	3.66	96.08	98	0.51	0.32	11.41	19	1.4	16.3	81.5	86.8	50.08	43.1	21.227	7.498	13.65	0.698	6.09	1.46	0.171	0.42
S-11	Min	20	17.5	467	215	6.9	3	20.5	2	4	12	4	244	144	21.9	37.962	3.2	14	2.83	0.05	0.8	0.05	0.13
	Max	32	28	837	536	8.8	4.8	62	46	9.2	56	288	320	248	152	133.93	42	83.24	5.04	8.94	4.54	1.1	1.06
	Avg.	25.27	22.9	724.5	445	7.982	4.085	42.2	24	6.6	28.5	192	253	181.2	78.3	81.784	11.69	51.12	3.868	1.05	2.06	0.27	0.43
	SD	4.24	3.6	98.47	97	0.49	0.521	11.15	16	1.6	21.7	76	86.8	27.79	46	26.787	11.07	23.3	1.514	2.78	1.5	0.469	0.36
S-12	Min	19	17	518	238	7.17	0.152	28	3	5.6	12	6.4	16	118	32.6	45.954	7.2	8.4	2.83	0.05	0.79	0.025	0.26
	Max	37	27	843	540	8.7	1	58	52	13	73.6	276	340	232	164	111.94	56	104.2	5.019	9.22	4.69	0.675	1.12
	Avg.	28.45	24.2	728.7	446	8.027	0.608	36.91	27	8.5	37.4	191	266	180.1	84	78.919	13.85	45.47	3.896	1.05	2.02	0.271	0.58
	SD	5.15	3.06	86.06	91	0.46	0.252	9.005	19	2.3	22.1	76.2	87.7	34.3	40.1	20.265	14.62	27.95	1.513	2.87	1.51	0.298	0.39

1. Air Temperature (^{0}C), 2. Water Temperature (^{0}C), 3. Conductivity (µs/cm), 4. Total Dissolved Solids (ppm), 5. pH, 6. Depth (m), 7. Secchi Transparency (cm), 8. Turbidity (NTU), 9. Dissolved Oxygen (mg./l), 10. Carbonate Alkalinity (mg/l), 11. Bicarbonate Alkalinity (mg./l), 12. Total Hardness (mg./l), 13. Calcium Hardness (mg./l), 14. Magnesium Hardness (mg./l), 15. Chlorides (mg/l), 16. Biochemical Oxygen Demand (mg/l), 17. Chemical Oxygen Demand (mg/l), 18. Nitrate Nitrogen (mg/l), 19. Ammonical Nitrogen (mg/l), 20. Phosphate (mg/l), 21. Total Iron (mg/l) and 22. Fluoride (mg/l)

4.2 Water quality observation of Shahpura Lake: (Shore line)

General parameter

pH: There was significant change in the pH value. The pH value ranged between 7.0 to 8.9. The highest value of 8.9 was recorded during the month of May- 2012 and and lowest value of 7.0 was recorded in Dec- 2010. The Maximum value 8.9 was recorded at Site S-12 while as the Minimum values 7.0 was recorded at Site S-7 (Fig 19).

Electrical Conductivity: Since the ions are the carries of electricity, the electrical conductivity of the water raises according to the content of soluble salts in the water. The value ranged between 520 to 1120 µs/cm. The Max value of 1120 was recorded in june 2012 and Min value of 520 was recorded oct-2010 in the Shahpura Lake. The Maximum value of 1120 was recorded at Site S-2 and Minimum value of 520was recorded at Site S -13 (Fig 20).

Total dissolved solids (TDS): Total dissolved solids are mainly the inorganic minerals and sometimes some organic matter. The TDS value ranged between 311to717 mg/l. the highest value of 717 mg/l was recorded June-2012 at site S-2 and lowest value of 311 mg/l was recorded at oct-2010 at the site of S-5 in this Lake. (Fig 21).

POLLUTION INDICATING PARAMETER

PERCENTAGE OF DISSOLVED OXYGEN:-The percentage D.O. has a great importance in an aquatic eco-system. It is considered as the pollution indicator parameter. It is reflects the biological activity taking place in a water body and also determines the biological changes, which is due to aerobic and anaerobic organisms. A common observation was that the bottom oxygen demand is low as compare to the surface water.

Percentage of D.O. ranged between 0.0 to 98.9%l in surface layer and in the bottom layer nil. Dissolved oxygen in the bottom layer generally observed was low because of higher microbial activity. Maximum D.O. percentage of 98.9% was observed at site S-10 being this point less pollution is observed and minimum D.O percentage 0.0% was observed at site S-2 this may be due to entry of raw sewage through char-imli nala (Fig 22).

NITRATE:-Nitrate is the important pollution indicating parameter. It is considered as important plant nutrient. Nitrate is the most oxidized or stable form of nitrogen. In shahpura lake the nitrate content of the water was in the range between 0.4 to 37.5mg/l. Higher concentration 37.5 of nitrate was found in site of S-2 March-2011 this may be due to untreated

raw sewage. The raw sewage is the source of nitrate and phosphate in the water.Minimum Nitrate 0.4 was observed at site S-5 in May-2012 during the pre-monsoon season. This may be due to the site being far away from points of sewage water. (Fig 23).

T-PHOSPHATE:- In the aquatic ecosystem inorganic phosphate as soluble O-phosphate play a dynamic role. The O-phosphate are readily taken up by the phytoplankton or lost to the sediments. In the eutrophic region high phosphate content supports an increased level of primary production till nitrogen become limiting. In Shahpura Lake range observed between 0.0 to 9.0 mg/l. the maximum T-phosphate 9.0mg/l was found at site S-4 in the month of May-2010 this may be due to nearby dense macrophyte growth and religious activities and minimum phosphate 0..0 was found at sites-5 this may be due to less pollution in this area. (Fig 24).

CHEMICAL OXYGEN DEMAND (COD): COD is an important parameter for knowing the quality of water, which analyzed by potassium dichromate open reflux method. High COD value may be due to presence of long chain of hydro-carbon for Ex organic matter like amino acid ,glucose. In shahpura lake COD range observed between 1.0 to 144.0mg/l. the maximum COD 144.0 mg/l was observed at site S-2 during the month of Nov-2010 which has untreated raw sewage and minimum COD 1.0 was observed at site S-12 Nov-2010 (Fig 25).

AMMONIACAL NITROGEN: When plants animal die, they decompose to produce ammonia is an oxidized to nitrite which is unstable and gets oxidized to Nitrate which is stable form of Nitrogen. As temperature increased NH3 gets released in to the atmosphere in the form of gas. In a shapura lake NH3 range between0.0 to 10.0mg/l. the maximum NH3-N 10.0mg/l was observed at site S-1,S-2,S-12 during the month of April,Jan,May-2010 which is very much higher than the permissible limit (0.3mg/l).This may be due to raw sewage entering into the lake and NH3-N 0.0mg/l was observed at site S-5 May-2011,S-7 Nov-2011, S-9 May&june-2012,S-10 Nov&Dec-2011,S-10 Feb&May-2012 and S-11Nov-2011 its indicates NH3-N has converted to Nitrite to Nitrate. (Fig -26)

Fluoride: The fluoride value ranged between 0.0 to 1.5 mg/l. During the study period lowest value observed 0.0mg/l and the highest value observed 1.5mg/l it was recorded at site S-01 Nov-2011.

Total Hardness: The Total Hardness value ranged between 120 to 340 mg/l. During the study period the highest value of 348 mg/l was noted in Feb 2012 and lowest value of 120 mg/l was noted in june2010. The maximum value of total hardness 340 mg/l was recorded at Site S-1 and while as minimum value of 120 mg/l was recorded at Site S-10 in this Lake .(Fig 27).

Major Ions

Carbonate ($CO3^-$): The Carbonate value ranged between 0.0 to 40.0 mg/l. the highest value of 40 mg/l noted in june-2012 maximum value of carbonate 40.0 mg/l was recorded at Site S-8 (Fig.28) .

Bicarbonate ($HCO3^-$): Bicarbonate value ranged between 109 to 392 mg/l. The highest value of 392 mg/l was noted in june -2011 and lowest value of 109mg/l was noted in June-2012. The Maximum value of 392 mg/l was recorded at Site S-12, and minimum value of109 mg/l was recorded at Site S -10 in Shahpura Lake (Fig 29).

Calcium Ion (Ca^{++}): The Calcium ion value ranging between 30.4 to 94mg/l. The highest value of 94mg/l was noted in may-2012 and lowest value of 30.4mg/l was noted in Oct-2010. The maximum value of 94 mg/l was recorded at site S-13 and minimum value of 30.4 mg/l was recorded at site S-5 in the Shahpura Lake .

Magnesium ion(Mg^{++}): The Magnesium ion value ranged between 7.3 to 61.0mg/l. The highest value of 61.0mg/l was recorded in May-2012 and lowest value of 7.3mg/l was recorded in Feb-2011. The Maximum value of 61.0 mg/l was recorded at Site S-2 and Minimum value of 7.3 mg/l was recorded at Site S-8 in this Lake.

Sodium (Na^+): The sodium value ranging between 25.0 to 92.0mg/l. The highest value of 92.0mg/l was recorded in july-2010and june-2011 and lowest value of 25.0mg/l was recorded in Feb-2011. The Maximum value of 92.0 mg/l was recorded at Site S-4&S-10 and Minimum value of 25.0 mg/l was recorded at Site S-1 in this Lake.

Potassium(k^+): The Potassium value ranging between 0.1 to 19.2mg/l. The highest value of 19.2mg/l was recorded in May-2010 and lowest value of 0.1mg/l was recorded in May-2011 and May-2012. The Maximum value of 19.2 mg/l was recorded at Site S-2and Minimum value of 0.1mg/l was recorded at Site S-4&S-12 in this Lake.

Chloride: The chloride value ranged between 42 to 145 mg/l. The highest value of 145 mg/l was noted in June-2011 at site S- 6 and lowest value of 42 mg/l was noted in September-2011 at site S-2 (Fig 30).

Sulphate: The sulphate value ranged between 4.0 to 92.0 mg/l. The highest value of 92.0 mg/l was noted in Dec-2011 at site S- 1 and lowest value of 4.0 mg/l was noted in Novr-2011 at site S-1 in the Shahpura lake.

General water quality parameters in Shahpura lake, Bhopal (MP) during year 2010 to 2012

Fig 19: Graphical presentation of pH in Shahpura lake.

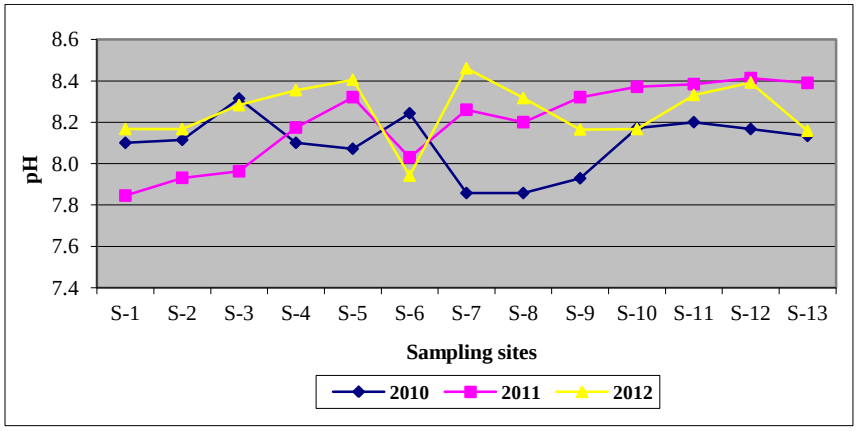


Fig 20: Graphical presentation of Conductivity in Shahpura lake

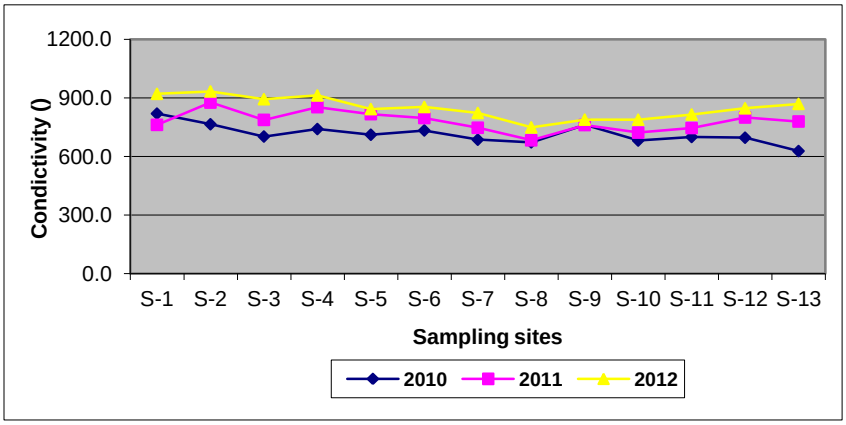
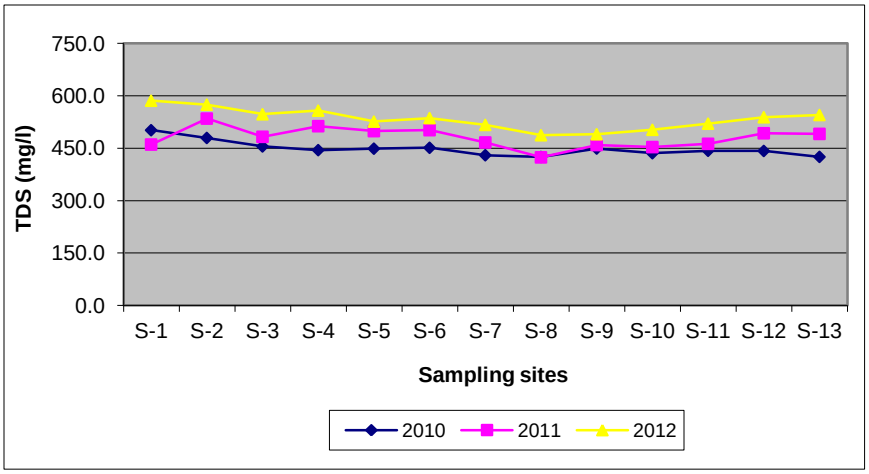


Fig 21: Graphical presentation of TDS in Shahpura lake



Pollution indicator parameters in Shahpura lake, Bhopal

Fig 22: Graphical presentation of NH3-N in Shahpura lake

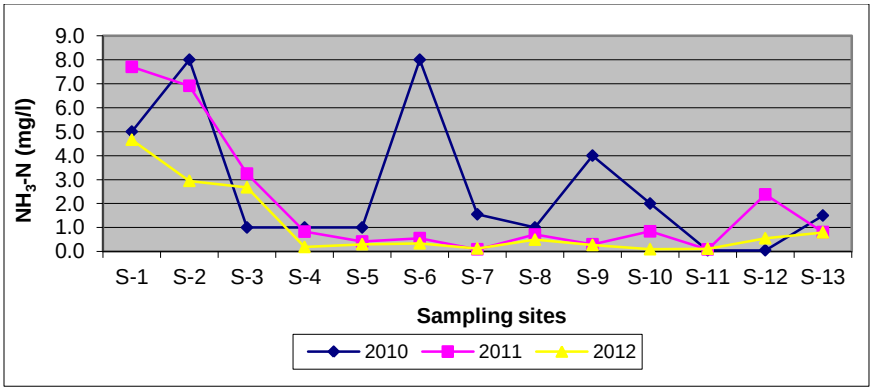


Fig 23: Graphical presentation of NO2-NO3 in Shahpura lake

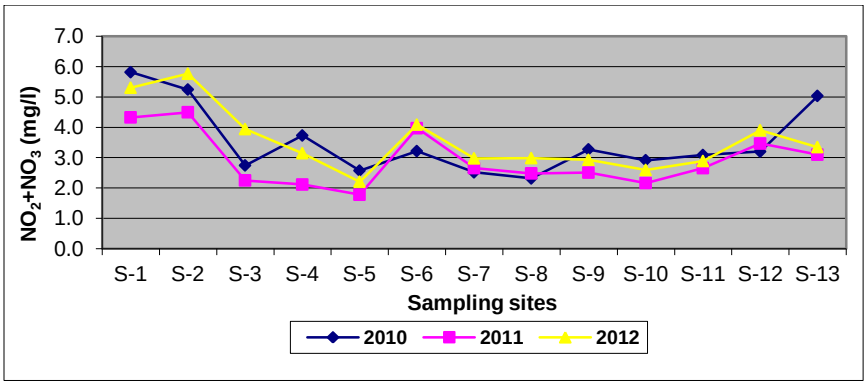


Fig 24: Graphical presentation of T-PO_4 in Shahpura lake

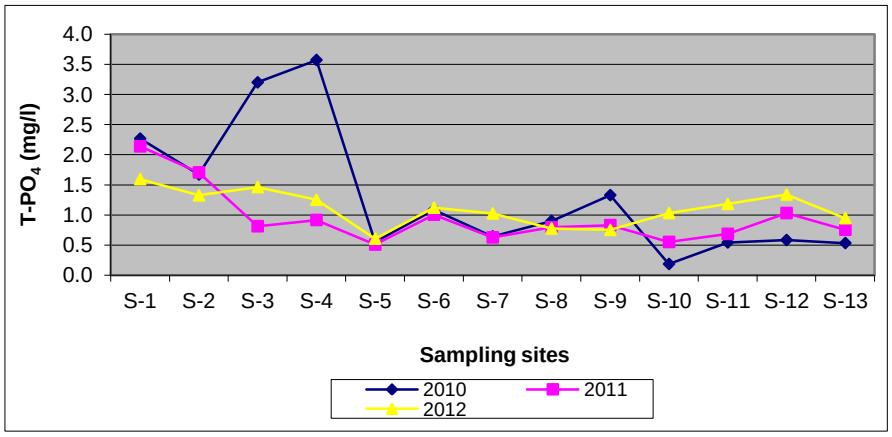


Fig 25: Graphical presentation of Iron in Shahpura lake

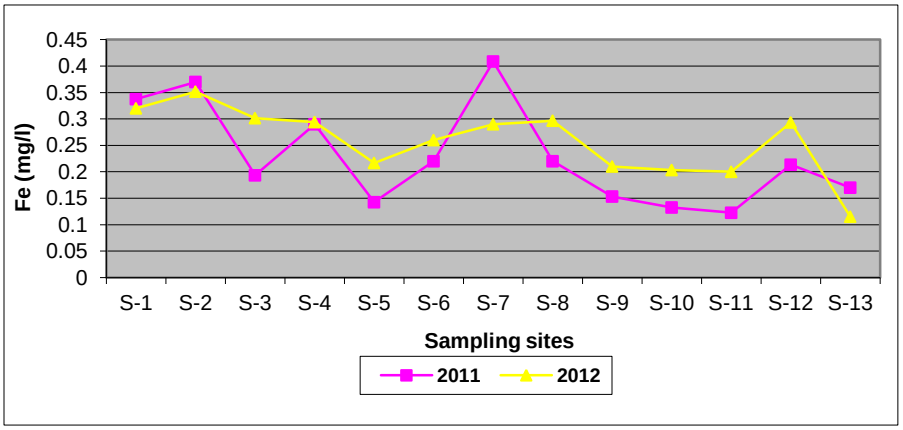


Fig 26: Graphical presentation of Fluoride in Shahpura lake

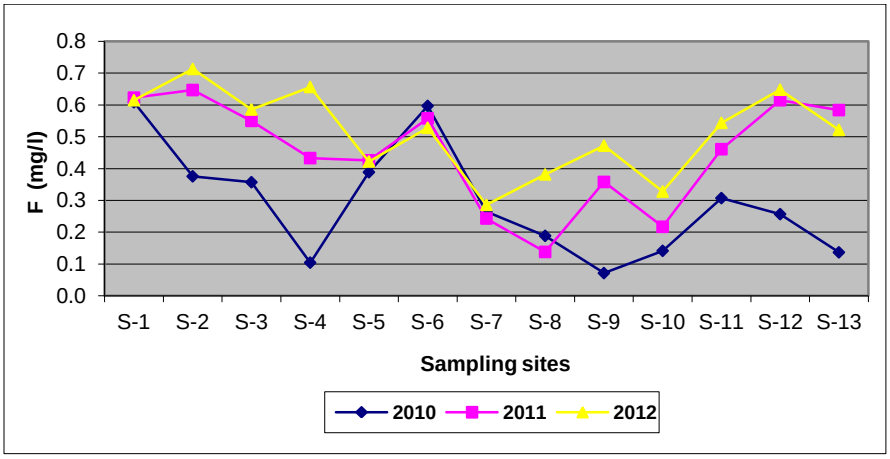


Fig 27: Graphical presentation of COD in Shahpura lake

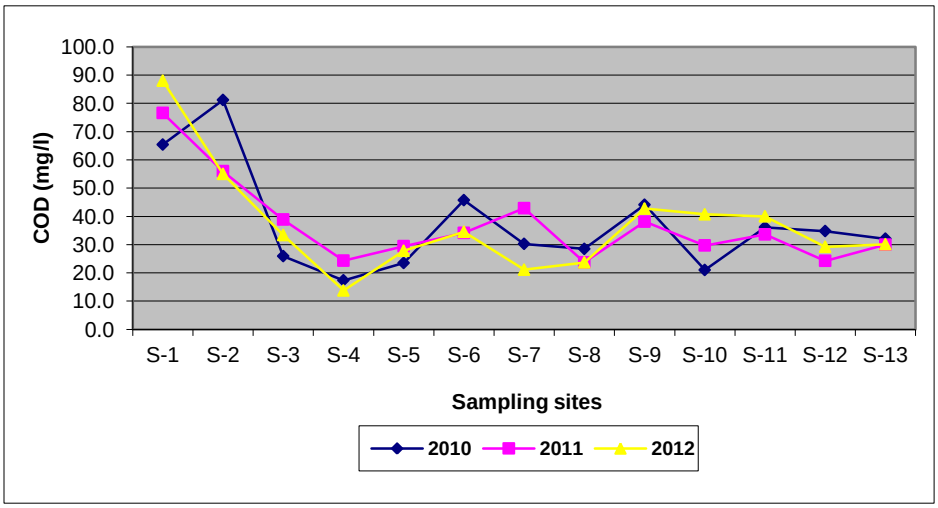


Fig 28: Graphical presentation of Temperature in Shahpura lake

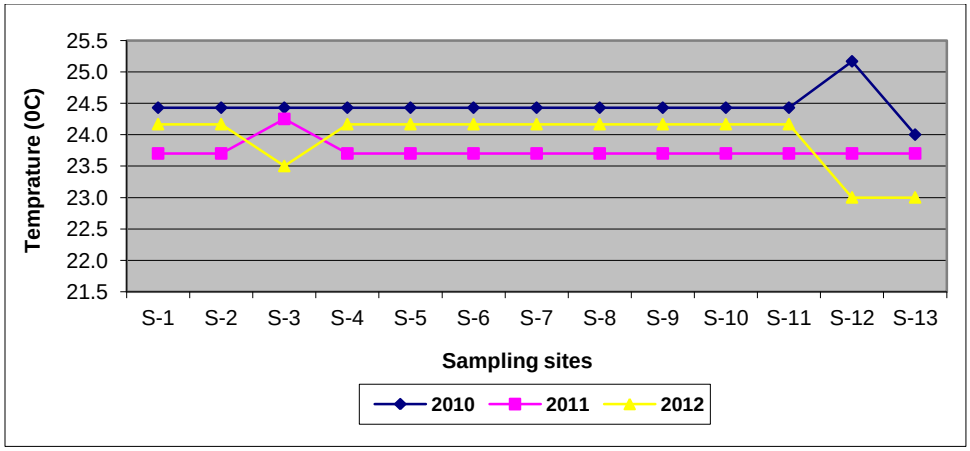


Fig 29: Fig Graphical presentation of DO in Shahpura lake

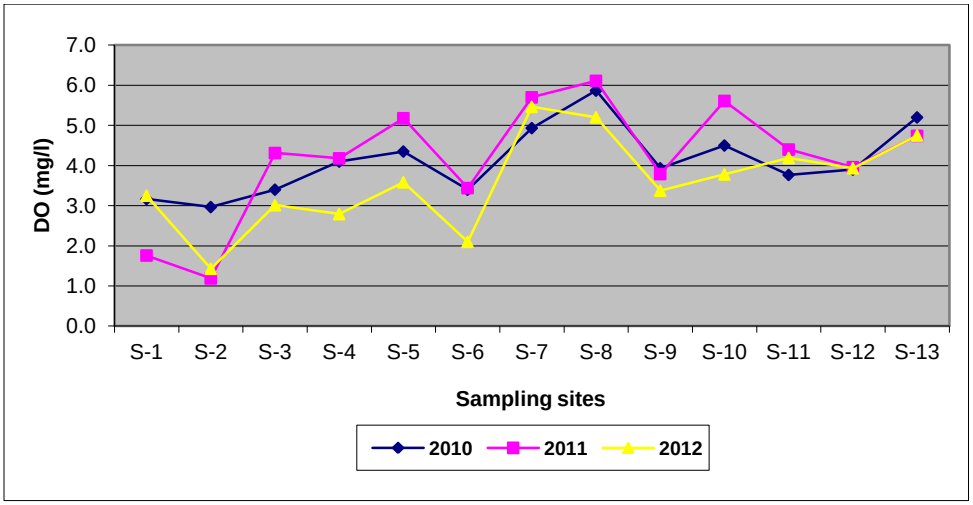
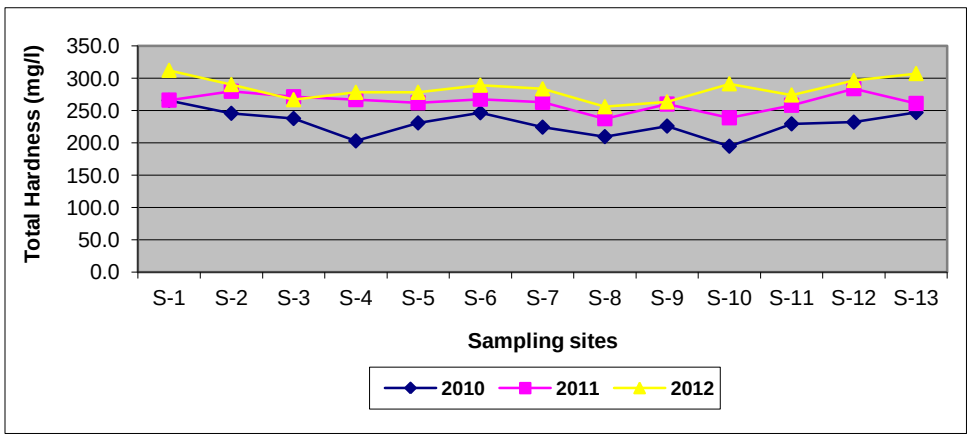


Fig 30: Graphical presentation of Tot-H in Shahpura lake



Major Ions in Shahpura lake

Fig 31: Graphical presentation of Ca ion in Shahpura lake

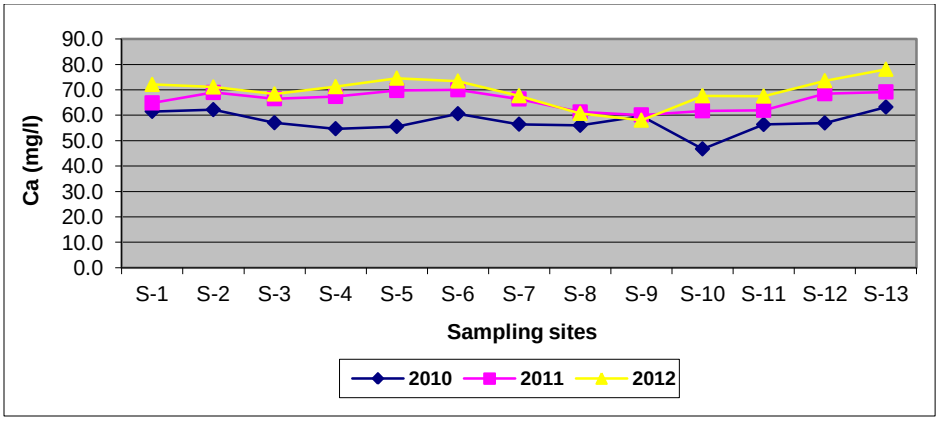


Fig 32: Graphical presentation of Mg ion in Shahpura lake

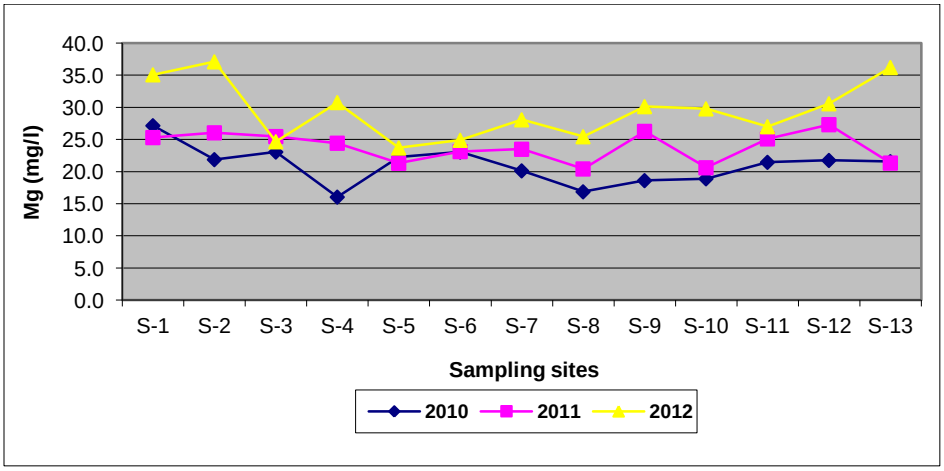


Fig 33: Graphical presentation of Sodium in Shahpura lake

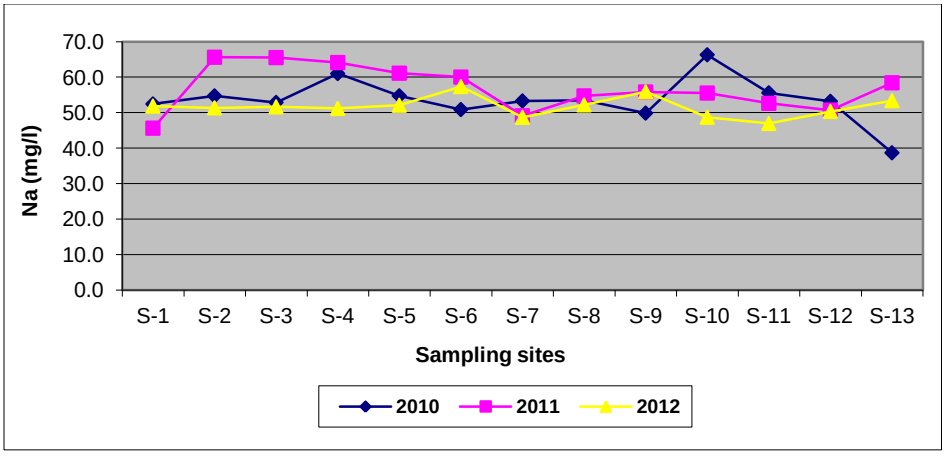


Fig 34: Graphical presentation of Potassium in Shahpura lake

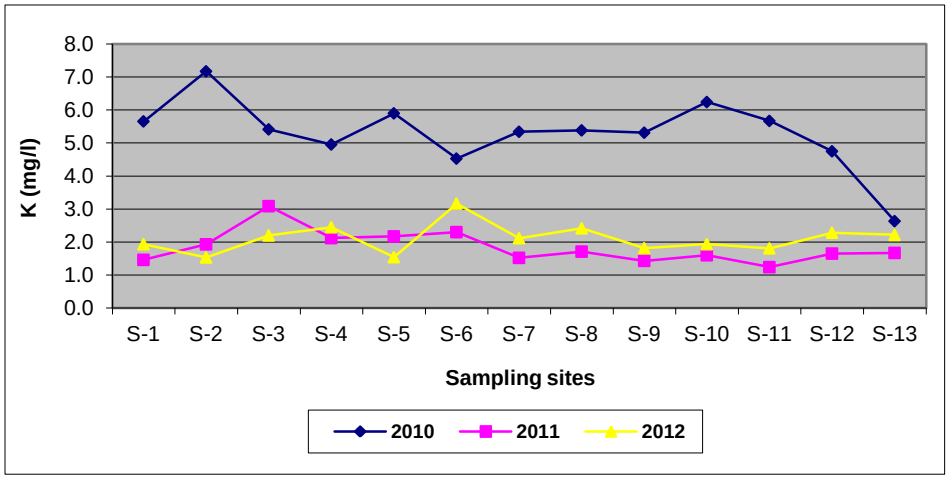


Fig 35: Graphical presentation of Chloride in Shahpura lake

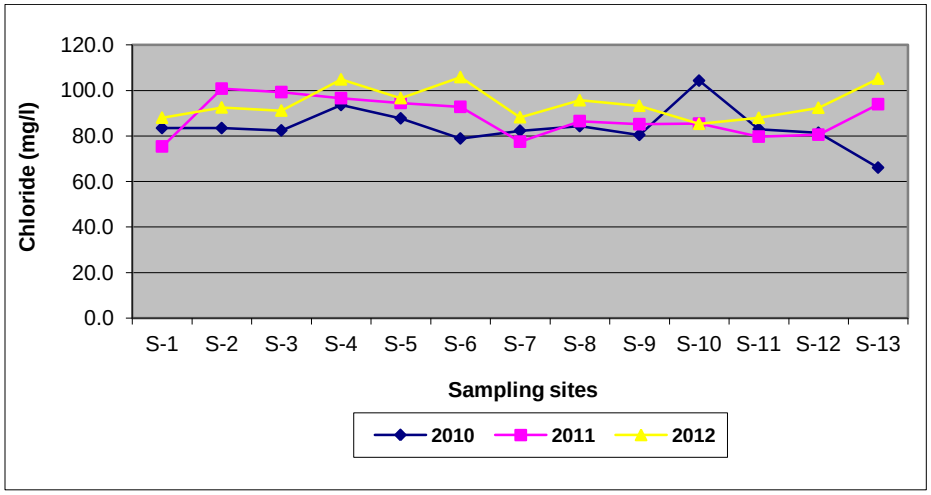


Fig 36: Graphical presentation of Sulphate in Shahpura lake

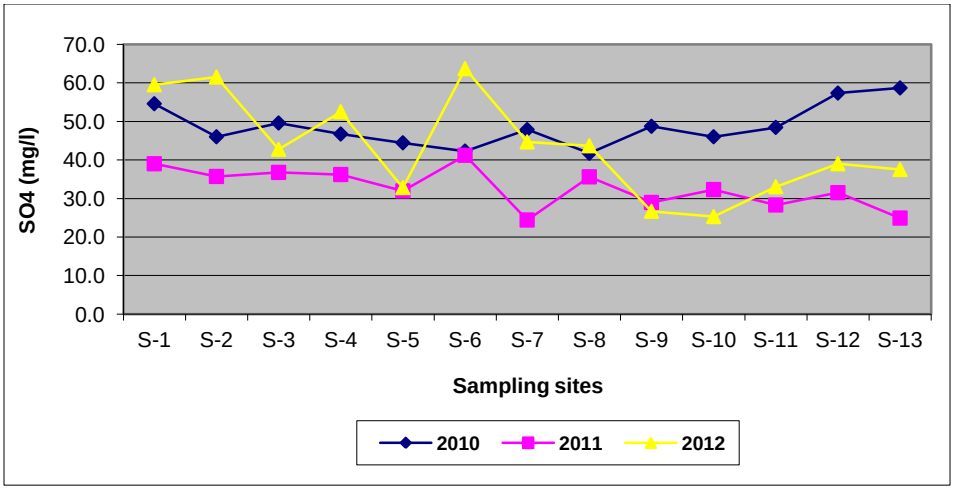


Fig 37: Graphical presentation of Carbonate in Shahpura lake

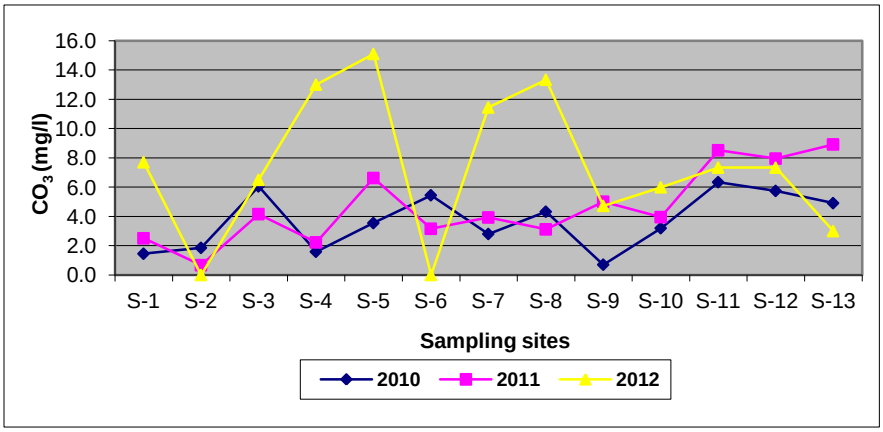


Fig 38: Graphical presentation of Bi-Carbonate in Shahpura lake

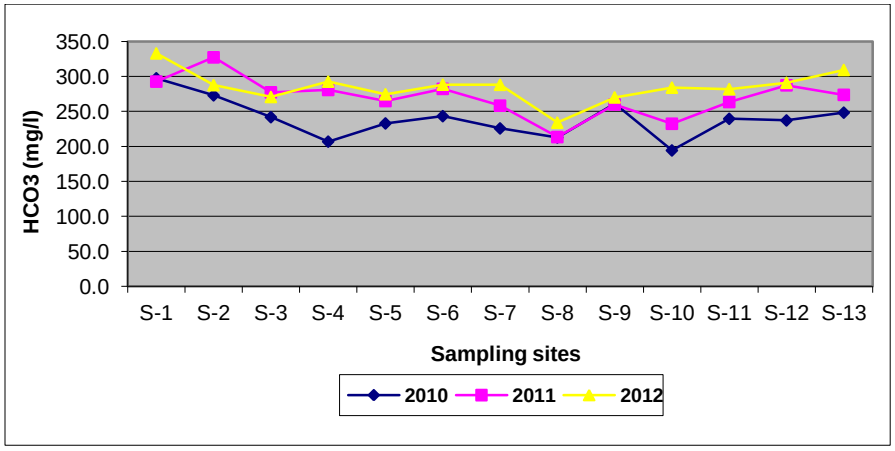


Table 5: Surface water (shore line) quality of Shahpura Lake (Year 2010)

State Water Quality Laboratory Level II +,Bhopal																				
Shoreline Surface Water Quality Data (April 2010 to June. 2012) of Shahpura Lake (WQ-PDS) HP II																				
Year 2010		General			Pollution indicator parameters								Hardness	Major Ions							
	Parameter	pH_GEN	EC_GEN	TDS	NH3-N	NO2+NO3	NO3-N	p-TOT	F	COD	Temp	DO	Har_T	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mg N/L	mgP/L	mg/L	mg/L	°C	mg/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
S-1	Avg	8.1	819.1	501.7	5.0	5.8	25.9	2.3	0.6	65.4	24.4	3.2	265.4	61.5	27.2	52.4	5.7	83.4	54.6	1.5	297.4
	Max	8.3	1000.0	620.0	5.0	8.0	35.7	6.0	1.1	104.0	27.0	3.3	322.0	67.2	39.4	80.0	13.5	128.0	71.0	4.4	388.0
	Min	8.0	688.0	448.0	5.0	3.8	16.9	0.0	0.1	38.0	20.0	3.0	220.0	56.8	14.6	38.0	1.0	66.0	40.0	0.0	226.5
	SD	0.1	129.2	69.8	0.0	1.7	7.4	2.1	0.5	29.7	2.6	0.2	34.9	3.8	7.8	13.5	5.3	20.8	12.2	1.9	64.0
S-2	Avg	8.1	764.7	479.6	8.0	5.2	23.4	1.7	0.4	81.2	24.4	3.0	245.4	62.2	21.9	54.7	7.2	83.4	46.0	1.9	273.1
	Max	8.4	830.0	535.0	9.0	9.0	40.1	3.0	1.0	144.0	27.0	3.1	256.0	67.2	24.3	72.0	19.2	114.0	74.0	5.8	341.6
	Min	7.9	674.0	431.0	7.0	2.5	11.2	1.0	0.1	48.5	20.0	2.8	232.0	57.6	20.4	39.0	1.1	68.0	18.0	0.0	231.6
	SD	0.2	67.7	39.4	1.4	2.4	10.7	0.8	0.4	38.2	2.6	0.2	10.4	3.5	1.2	9.9	7.3	16.1	21.3	2.5	39.8
S-3	Avg	8.3	701.9	455.3	1.0	2.7	12.2	3.2	0.4	25.9	24.4	3.4	237.4	57.0	23.1	52.9	5.4	82.4	49.6	6.1	241.9
	Max	8.5	754.0	511.0	1.0	3.6	16.1	5.4	1.0	41.2	27.0	3.5	288.0	75.2	29.2	68.0	16.8	105.0	87.0	14.4	302.6
	Min	8.0	595.0	380.0	1.0	1.6	7.1	0.0	0.0	11.4	20.0	3.2	200.0	40.0	18.5	35.0	1.4	62.0	26.0	2.2	193.7
	SD	0.2	53.9	39.6	0.0	0.8	3.5	2.2	0.4	11.2	2.6	0.2	33.5	15.3	3.5	11.9	5.8	17.2	23.3	4.2	33.1
S-4	Avg	8.1	740.1	444.7	1.0	3.7	16.6	3.6	0.1	17.3	24.4	4.1	202.7	54.7	16.0	61.0	5.0	93.6	46.7	1.6	206.9
	Max	8.5	949.0	524.0	1.0	7.2	32.1	9.0	0.3	25.7	27.0	4.2	236.0	73.6	23.3	88.0	12.0	121.0	60.0	4.8	239.1
	Min	7.9	648.0	384.0	1.0	2.0	8.9	0.0	0.0	5.6	20.0	4.0	166.0	42.4	9.7	39.0	1.4	65.0	40.0	0.0	163.5
	SD	0.2	110.0	45.4	0.0	2.0	9.1	3.7	0.1	7.2	2.6	0.1	27.9	11.1	4.9	20.7	4.6	25.1	7.5	1.8	27.3
S-5	Avg	8.1	711.0	448.9	1.0	2.6	11.5	0.6	0.4	23.5	24.4	4.4	230.6	55.5	22.3	54.7	5.9	87.7	44.4	3.5	232.9
	Max	8.4	771.0	553.0	1.0	5.5	24.5	1.0	1.2	59.2	27.0	4.5	280.0	73.6	25.3	72.0	17.0	116.0	72.0	9.6	327.0
	Min	7.7	565.0	311.0	1.0	0.8	3.6	0.0	0.0	10.0	20.0	4.2	174.0	30.4	10.7	36.0	1.4	62.0	26.0	1.0	166.4
	SD	0.3	72.3	77.5	0.0	1.5	6.5	0.4	0.5	17.3	2.6	0.2	38.1	17.2	5.2	15.8	6.4	21.3	14.6	3.2	53.3
S-6	Avg	8.2	733.0	451.4	8.0	3.2	14.3	1.1	0.6	45.7	24.4	3.4	246.3	60.6	23.1	50.9	4.5	78.9	42.3	5.4	243.3
	Max	8.4	880.0	524.0	8.0	5.9	26.3	2.0	1.0	123.0	27.0	3.5	280.0	73.6	25.3	64.0	15.2	98.0	75.0	14.4	307.4
	Min	8.0	650.0	389.0	8.0	1.1	4.9	0.7	0.1	18.0	20.0	3.2	212.0	43.2	20.4	37.0	0.9	60.0	16.0	1.8	186.2
	SD	2.2	230.3	141.5	0.0	2.1	9.5	1.6	0.3	30.8	6.4	1.6	74.4	19.0	9.2	19.3	3.9	28.9	21.3	6.8	81.8

Year 2010		General			Pollution indicator parameters								Hardness	Major Ions							
	Parameter	pH_GEN	EC_GEN	TDS	NH3-N	NO2+NO3	NO3-N	p-TOT	F	COD	Temp	DO	Har_T	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mg N/L	mgP/L	mg/L	mg/L	ºC	mg/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
S-7	Avg	7.9	685.6	430.0	1.6	2.5	11.2	0.6	0.3	30.2	24.4	4.9	224.0	56.5	20.1	53.3	5.3	82.3	47.9	2.8	225.8
	Max	8.4	769.0	505.0	3.1	4.7	21.0	2.0	0.6	68.4	27.0	5.0	268.0	72.0	26.2	70.0	16.9	106.0	79.0	9.6	295.2
	Min	7.0	550.0	370.0	0.1	1.1	4.9	0.0	0.1	8.0	20.0	4.8	200.0	38.4	9.7	38.0	1.4	58.0	28.0	0.0	195.0
	SD	0.5	83.8	49.0	2.1	1.3	6.0	0.7	0.2	21.3	2.6	0.1	27.2	13.2	5.4	14.3	5.6	18.0	19.6	3.6	36.2
S-8	Avg	7.9	672.1	425.1	1.0	2.3	10.3	0.9	0.2	28.5	24.4	5.9	209.4	56.0	16.9	53.4	5.4	84.3	41.7	4.3	212.8
	Max	8.5	810.0	524.0	1.0	2.8	12.5	2.0	1.0	64.0	27.0	5.9	290.0	78.4	22.8	72.0	16.8	115.0	62.0	24.0	292.8
	Min	7.5	550.0	356.0	1.0	1.8	8.0	0.0	0.0	15.0	20.0	5.8	140.0	35.2	9.2	41.0	1.3	64.0	18.0	0.0	151.3
	SD	0.4	95.7	63.8	0.0	0.4	1.9	0.8	0.4	20.0	2.6	0.1	57.6	16.1	5.0	13.2	6.2	18.3	15.2	9.0	54.8
S-9	Avg	7.9	762.0	449.3	4.0	3.3	14.6	1.3	0.1	44.1	24.4	3.9	225.7	59.7	18.6	49.9	5.3	80.4	48.7	0.7	261.1
	Max	8.1	880.0	493.0	4.0	4.0	17.8	2.0	0.2	70.0	27.0	4.0	244.0	67.2	25.3	76.0	14.0	102.0	68.0	1.8	307.4
	Min	7.8	648.0	415.0	4.0	2.3	10.3	0.0	0.0	20.0	20.0	3.8	212.0	54.4	14.6	38.0	1.1	66.0	40.0	0.0	226.3
	SD	0.1	92.5	29.5	0.0	0.7	3.0	0.7	0.1	19.0	2.6	0.1	13.4	5.1	4.7	13.0	5.6	12.2	10.5	0.9	30.0
S-10	Avg	8.2	681.3	435.9	2.0	2.9	13.0	0.2	0.1	21.0	24.4	4.5	194.6	46.7	18.9	66.3	6.2	104.3	46.0	3.2	194.3
	Max	8.4	724.0	463.0	2.0	4.2	18.7	0.3	0.2	24.0	27.0	4.6	234.0	65.6	32.1	92.0	15.0	140.0	70.0	4.6	235.5
	Min	7.6	635.0	406.0	2.0	1.7	7.6	0.0	0.1	16.0	20.0	4.4	120.0	33.6	8.8	44.0	1.8	72.0	26.0	0.0	109.3
	SD	0.3	33.8	18.9	0.0	1.1	5.0	0.1	0.1	2.6	2.6	0.1	35.9	11.9	8.2	18.7	5.8	27.9	19.6	1.6	40.0
S-11	Avg	8.2	699.6	442.9	0.1	3.1	13.8	0.5	0.3	36.1	24.4	3.8	229.1	56.3	21.5	55.6	5.7	83.0	48.4	6.3	239.5
	Max	8.5	771.0	481.0	0.1	4.6	20.5	0.9	1.3	68.4	27.0	3.8	260.0	68.8	24.3	68.0	17.2	104.0	85.0	19.2	312.3
	Min	7.8	615.0	393.0	0.1	1.7	7.6	0.3	0.0	15.0	20.0	3.7	192.0	38.4	18.5	37.0	1.4	53.9	20.0	1.3	195.3
	SD	0.3	63.1	34.2	0.0	1.1	4.8	0.3	0.5	22.2	2.6	0.1	23.3	12.5	2.5	12.2	5.9	18.8	23.4	6.1	37.8
S-12	Avg	8.2	695.8	442.3	0.1	3.2	14.3	0.6	0.3	34.8	25.2	3.9	231.8	56.9	21.7	53.2	4.8	81.4	57.3	5.7	237.2
	Max	8.5	794.0	545.0	0.1	4.6	20.5	1.3	0.6	73.0	27.0	4.1	268.0	73.6	26.2	68.0	16.9	104.0	90.0	19.2	322.1
	Min	7.8	619.0	396.0	0.1	1.6	7.1	0.0	0.1	1.0	23.0	3.7	196.0	38.4	13.1	36.0	1.4	63.0	30.0	1.4	210.4
	SD	0.3	80.0	54.7	0.0	1.2	5.4	0.4	0.2	32.9	1.8	0.2	24.5	14.6	4.8	12.1	6.0	18.1	22.7	6.8	42.5
S-13	Avg	8.1	627.3	425.3	1.5	5.0	22.4	0.5	0.1	32.1	24.0	5.2	246.7	63.2	21.6	38.7	2.6	66.1	58.7	4.9	248.3
	Max	8.6	690.0	476.0	2.0	5.2	23.2	1.0	0.3	41.2	26.0	5.5	268.0	71.2	24.3	41.0	3.7	69.0	69.0	9.5	276.7
	Min	7.5	520.0	370.0	1.0	4.7	21.0	0.1	0.0	20.0	23.0	5.0	208.0	52.8	18.5	36.0	1.5	64.0	53.0	0.0	213.4
	SD	0.6	93.4	53.2	0.7	0.3	1.3	0.5	0.2	10.9	1.7	0.3	33.5	9.4	2.9	2.5	1.1	2.6	9.0	4.8	32.2

Table 6: Surface water (shore line) quality of Shahpura lake (Year 2011)

State Water Quality Laboratory Level II +,Bhopal																						
Shoreline Surface Water Quality Data (April 2010 to June. 2012) of Shahpura Lake (WQ-PDS) HP II																						
Year 2011		General			Pollution indicator parameters									Hardness	Major Ions							
	Parameter	pH_GEN	EC_GEN	TDS	NH3-N	NO2+NO3	NO3-N	p-TOT	Fe	F	COD	Temp	DO	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	°C	mg/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
S-1	Avg	7.8	761.7	460.7	7.7	4.3	19.3	2.1	0.3	0.6	76.6	23.7	1.8	265.9	64.8	25.3	45.6	1.5	75.4	39.0	2.5	292.7
	Max	8.3	960.0	544.0	10.0	8.2	36.6	4.5	0.4	1.5	130.6	27.0	4.0	328.0	75.2	36.5	55.0	3.3	96.0	92.0	12.0	356.2
	Min	7.3	646.0	370.0	3.9	1.9	8.5	0.1	0.3	0.0	44.0	19.0	0.0	208.0	48.0	12.2	25.0	0.3	38.0	4.0	0.0	232.0
	SD	0.3	95.6	46.6	1.8	1.9	8.6	1.6	0.0	0.4	29.7	2.8	1.8	50.6	9.2	9.3	9.3	1.0	17.1	26.9	3.6	37.0
S-2	Avg	7.9	875.9	535.1	6.9	4.5	20.0	1.7	0.4	0.6	56.0	23.7	1.2	279.6	68.9	26.0	65.6	1.9	100.8	35.7	0.7	327.4
	Max	8.4	980.0	580.0	10.0	8.4	37.5	3.0	0.4	1.0	92.0	27.0	3.7	300.0	76.0	33.1	90.0	5.4	125.0	82.0	2.9	402.0
	Min	7.7	720.0	470.0	1.3	0.7	3.1	0.9	0.4	0.0	15.7	19.0	0.0	256.0	59.2	22.8	35.0	0.2	60.8	10.0	0.0	252.1
	SD	0.3	70.1	32.8	2.3	2.8	12.4	0.8	0.0	0.4	26.9	2.8	1.1	12.7	5.6	3.5	18.7	2.0	20.3	28.3	1.1	56.5
S-3	Avg	8.0	787.0	482.9	3.2	2.3	10.0	0.8	0.2	0.6	38.9	24.3	4.3	271.0	66.5	25.5	65.5	3.1	99.3	36.8	4.2	277.4
	Max	8.6	930.0	547.0	6.0	5.0	22.3	2.0	0.2	1.0	56.9	27.0	5.0	300.0	76.0	34.5	90.0	5.9	130.0	68.0	15.4	322.6
	Min	7.5	674.0	380.0	0.5	0.5	2.2	0.0	0.2	0.4	22.0	19.0	3.0	228.0	51.2	20.9	35.0	0.2	58.0	10.0	0.0	241.1
	SD	0.4	80.4	54.7	2.3	1.9	8.7	0.6	0.0	0.2	12.8	2.8	0.7	21.7	8.6	4.6	21.4	2.2	27.4	23.2	5.9	30.5
S-4	Avg	8.2	852.5	513.3	0.8	2.1	9.4	0.9	0.3	0.4	24.3	23.7	4.2	266.7	67.4	24.4	64.1	2.1	96.6	36.2	2.2	280.8
	Max	8.5	965.0	576.0	3.0	4.0	17.8	1.1	0.3	1.0	50.6	27.0	5.5	306.0	85.6	31.1	92.0	6.2	136.0	68.0	7.8	336.7
	Min	7.7	717.0	411.0	0.1	0.4	1.8	0.5	0.2	0.0	8.0	19.0	3.1	212.0	48.0	20.7	37.0	0.1	62.0	14.0	0.0	237.1
	SD	0.2	88.0	59.3	1.1	1.5	6.9	0.2	0.0	0.3	15.1	2.8	0.9	31.3	12.9	3.0	18.9	2.1	25.8	20.5	3.0	31.7
S-5	Avg	8.3	816.5	499.2	0.4	1.8	7.9	0.5	0.1	0.4	29.4	23.7	5.2	261.8	69.7	21.3	61.1	2.2	94.5	32.0	6.6	264.9
	Max	8.4	978.0	570.0	1.0	3.6	15.9	0.9	0.2	0.7	50.6	27.0	6.0	292.0	80.8	24.8	89.0	5.0	133.0	64.0	19.4	316.7
	Min	8.1	638.0	362.0	0.0	0.1	0.4	0.1	0.1	0.0	15.0	19.0	4.1	204.0	51.2	15.1	36.0	0.2	58.0	5.5	1.0	239.0
	SD	0.1	102.7	64.5	0.4	1.0	4.7	0.3	0.1	0.3	11.5	2.8	0.6	25.1	8.8	3.2	20.4	1.9	26.6	21.4	5.1	23.3
S-6	Avg	8.0	796.7	502.0	0.6	4.0	17.7	1.0	0.2	0.6	34.1	23.7	3.4	267.4	70.0	23.1	60.0	2.3	92.8	41.2	3.2	282.3
	Max	8.5	920.0	592.0	2.7	8.2	36.6	1.6	0.3	1.0	56.9	27.0	7.2	298.0	81.2	29.7	90.0	4.9	145.0	80.0	24.0	375.8
	Min	7.5	613.0	365.0	0.1	0.3	1.3	0.7	0.2	0.1	15.7	19.0	0.0	212.0	54.4	18.0	35.0	0.2	54.0	12.0	0.0	209.8
	SD	0.3	100.1	79.5	0.8	2.8	12.3	0.2	0.0	0.4	15.2	2.8	2.7	29.1	8.7	4.2	19.5	1.7	28.6	26.4	7.4	43.5

Year 2011		General			Pollution indicator parameters									Hardness	Major Ions							
	Parameter	pH_GEN	EC_GEN	TDS	NH3-N	NO2+NO3	NO3-N	p-TOT	Fe	F	COD	Temp	DO	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	°C	mg/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
S-7	Avg	8.3	746.8	466.6	0.1	2.7	11.8	0.6	0.4	0.2	42.9	23.7	5.7	262.5	66.4	23.5	49.1	1.5	77.5	24.4	3.9	258.3
	Max	8.4	890.0	570.0	0.2	6.0	26.8	1.0	0.5	0.5	111.0	27.0	7.0	288.0	84.0	29.2	81.0	4.0	110.0	44.0	6.5	291.2
	Min	8.0	578.0	328.0	0.0	0.5	2.2	0.0	0.3	0.0	11.5	19.0	4.1	212.0	48.0	16.0	29.0	0.2	42.0	16.0	0.0	234.3
	SD	0.2	93.2	73.4	0.1	2.1	9.4	0.3	0.1	0.2	31.6	2.8	0.9	24.5	11.2	4.1	18.9	1.3	23.2	9.2	2.3	18.0
S-8	Avg	8.2	682.5	424.0	0.7	2.5	11.1	0.8	0.2	0.1	23.7	23.7	6.1	237.2	61.3	20.4	54.7	1.7	86.5	35.6	3.1	213.5
	Max	8.4	880.0	540.0	1.2	3.0	13.4	1.5	0.2	0.4	38.0	27.0	6.8	308.0	75.0	34.1	86.0	3.6	130.0	60.0	6.7	283.2
	Min	7.6	560.0	365.0	0.1	2.0	8.9	0.0	0.2	0.0	12.0	19.0	5.2	160.0	49.6	7.3	42.0	0.5	65.0	20.0	0.0	121.6
	SD	0.3	104.1	64.2	0.5	0.4	1.6	0.4	0.0	0.2	10.4	2.8	0.5	49.4	9.6	8.2	17.1	1.0	22.8	17.0	2.5	56.9
S-9	Avg	8.3	760.7	459.3	0.3	2.5	11.2	0.8	0.2	0.4	38.1	23.7	3.8	259.8	60.1	26.3	55.8	1.4	85.1	29.0	5.0	260.0
	Max	8.5	876.0	565.6	1.0	5.6	25.0	1.0	0.2	0.8	61.4	27.0	5.9	296.0	73.6	37.7	85.0	3.8	117.0	62.0	14.4	302.6
	Min	8.1	625.0	344.0	0.0	0.6	2.7	0.4	0.1	0.0	7.9	19.0	0.3	212.0	48.0	20.4	31.0	0.2	48.0	10.0	0.0	239.1
	SD	0.1	75.8	65.8	0.4	2.0	8.7	0.2	0.0	0.3	18.6	2.8	2.1	27.1	9.0	4.8	19.6	1.4	25.0	18.0	4.2	19.8
S-10	Avg	8.4	722.0	453.4	0.8	2.2	9.6	0.6	0.1	0.2	29.7	23.7	5.6	238.6	61.7	20.6	55.5	1.6	85.4	32.3	4.0	232.4
	Max	8.5	780.0	499.0	3.0	4.0	17.8	1.1	0.2	0.6	43.0	27.0	8.0	276.0	73.6	31.1	88.0	4.0	132.0	68.0	6.2	272.8
	Min	8.2	680.0	421.0	0.0	0.7	3.1	0.1	0.1	0.0	12.0	19.0	4.2	212.0	48.0	10.2	36.0	0.2	59.0	10.0	0.0	184.0
	SD	0.1	29.8	24.5	1.1	1.4	6.4	0.4	0.0	0.2	10.9	2.8	1.1	21.3	8.0	7.2	18.2	1.3	21.1	21.2	2.3	31.9
S-11	Avg	8.4	745.6	462.8	0.1	2.7	11.8	0.7	0.1	0.5	33.6	23.7	4.4	258.0	61.9	25.1	52.6	1.2	79.7	28.3	8.5	263.5
	Max	8.6	875.0	560.0	0.4	5.2	23.2	1.0	0.2	0.6	50.6	27.0	5.5	284.0	72.0	30.1	80.0	2.6	120.0	58.0	24.2	292.3
	Min	8.1	655.0	371.0	0.0	0.6	2.7	0.4	0.1	0.0	17.9	19.0	3.2	216.0	49.6	21.4	36.0	0.1	56.0	11.0	1.0	247.3
	SD	0.1	63.8	58.5	0.1	2.0	8.8	0.2	0.0	0.2	10.7	2.8	0.7	24.2	7.3	2.8	17.4	0.8	21.8	15.4	7.3	12.6
S-12	Avg	8.4	799.4	493.0	2.4	3.5	15.4	1.0	0.2	0.6	24.2	23.7	4.0	283.7	68.5	27.3	50.7	1.7	80.5	31.5	8.0	287.4
	Max	8.6	940.0	581.1	10.0	5.2	23.2	4.0	0.4	1.1	50.6	27.0	6.0	322.0	80.0	34.0	65.0	4.6	104.0	65.0	15.1	392.5
	Min	8.2	678.0	373.0	0.0	0.8	3.6	0.4	0.1	0.2	8.0	19.0	0.3	248.0	52.0	22.6	35.0	0.2	62.7	10.0	0.6	235.0
	SD	0.1	93.0	66.9	3.8	1.7	7.7	1.1	0.1	0.3	15.2	2.8	2.0	24.9	9.7	3.8	9.6	1.4	14.3	18.8	3.7	45.8
S-13	Avg	8.4	778.8	491.2	0.8	3.1	13.8	0.8	0.2	0.6	29.9	23.7	4.7	260.7	69.2	21.3	58.4	1.7	93.9	24.9	8.9	273.7
	Max	8.6	908.0	581.1	2.0	5.2	23.2	1.0	0.2	1.0	50.1	27.0	5.4	300.0	86.4	25.2	84.0	4.9	124.0	48.0	24.0	331.8
	Min	8.0	701.0	423.0	0.1	0.5	2.2	0.2	0.2	0.3	17.9	19.0	3.0	220.0	52.8	19.4	42.0	0.2	68.2	10.0	0.0	252.0
	SD	0.2	60.8	44.3	0.7	1.8	8.1	0.3	0.0	0.3	11.3	2.8	0.7	25.2	10.9	1.9	13.9	1.6	17.2	12.3	7.8	24.4

Table 7: Surface water (shore line) quality of Shahpura Lake (Year 2012)

State Water Quality Laboratory Level II +,Bhopal																					
Shoreline Surface Water Quality Data (April 2010 to June. 2012) of Shahpura Lake (WQ-PDS) HP II																					
Year 2012		General			Pollution indicator parameters									Hardness	Major Ions							
	Parameter	pH_GEN	EC_GEN	TDS	NH3-N	NO2+NO3	NO3-N	p-TOT	Fe	F	COD	Temp	DO	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	^{o}C	mg/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
S-1	Avg	8.2	920.5	586.2	4.7	5.3	23.6	1.6	0.3	0.6	88.0	24.2	3.3	312.0	72.1	35.1	51.8	1.9	88.0	59.5	7.7	333.0
	Max	8.3	1000.0	640.0	7.7	5.7	25.4	2.7	0.5	0.7	118.0	27.0	4.2	340.0	82.0	42.0	55.0	3.0	98.0	66.0	16.0	352.0
	Min	7.9	820.0	520.0	0.3	4.9	21.9	0.3	0.2	0.6	72.0	19.0	1.5	276.0	66.0	27.0	45.0	1.3	76.0	54.0	0.0	312.0
	SD	0.2	59.5	51.6	3.4	0.3	1.4	0.9	0.1	0.0	16.6	3.1	1.0	24.8	5.6	5.5	3.7	0.6	7.5	5.0	6.5	14.8
S-2	Avg	8.2	932.8	574.8	2.9	5.8	25.7	1.3	0.4	0.7	55.0	24.2	1.4	290.0	71.1	37.1	51.3	1.5	92.5	61.5	0.0	287.7
	Max	8.4	1120.0	717.0	8.2	7.4	33.0	1.7	0.4	0.9	62.0	27.0	1.9	310.0	78.0	61.0	58.0	1.8	107.0	74.0	0.0	312.0
	Min	8.0	787.0	504.0	0.5	3.4	15.2	0.9	0.3	0.6	40.0	19.0	1.0	272.0	63.1	25.0	41.0	1.2	78.0	48.0	0.0	266.0
	SD	0.1	111.4	77.3	3.5	1.6	7.2	0.3	0.0	0.1	7.8	3.1	0.3	13.4	5.0	13.6	5.7	0.2	9.5	9.2	0.0	15.7
S-3	Avg	8.3	893.1	547.4	2.7	3.9	17.6	1.5	0.3	0.6	33.4	23.5	3.0	266.6	68.3	24.7	51.6	2.2	91.1	42.8	6.5	270.8
	Max	8.5	980.0	604.0	4.2	5.3	23.6	2.5	0.4	0.7	70.9	27.0	3.8	284.0	74.0	28.0	65.0	3.9	110.0	56.0	24.0	300.0
	Min	8.0	830.0	465.0	1.2	1.4	6.2	0.6	0.2	0.5	20.0	19.0	2.0	236.0	55.1	22.3	34.0	1.3	59.0	16.0	0.0	254.0
	SD	0.2	49.6	45.6	1.1	1.3	5.6	0.6	0.1	0.1	16.6	3.0	0.7	15.5	6.1	1.9	11.0	0.8	19.3	14.4	10.0	17.7
S-4	Avg	8.4	912.2	557.7	0.2	3.1	14.0	1.3	0.3	0.7	13.7	24.2	2.8	278.0	71.2	30.8	51.2	2.4	104.8	52.5	13.0	292.7
	Max	8.5	990.0	608.0	0.2	3.5	15.6	1.4	0.3	0.8	23.0	27.0	3.4	288.0	76.0	38.0	65.0	3.5	128.0	64.0	24.0	344.0
	Min	8.2	863.0	512.0	0.1	2.6	11.7	1.1	0.3	0.6	6.5	19.0	2.1	264.0	64.0	25.4	39.0	1.1	81.0	38.0	0.0	262.0
	SD	0.1	48.1	36.1	0.0	0.4	1.6	0.1	0.0	0.1	6.8	3.1	0.5	7.8	4.5	5.4	9.8	1.0	16.9	10.5	8.4	29.4
S-5	Avg	8.4	842.5	526.4	0.3	2.2	9.8	0.6	0.2	0.4	27.8	24.2	3.6	278.0	74.6	23.7	52.1	1.5	96.6	32.8	15.1	274.7
	Max	8.5	900.0	580.0	0.8	3.2	14.3	1.3	0.3	0.5	32.2	27.0	4.3	292.0	83.1	34.0	62.0	2.0	126.0	44.0	36.0	310.0
	Min	8.2	800.0	474.6	0.1	1.3	6.0	0.1	0.1	0.2	23.0	19.0	2.7	264.0	68.2	18.0	30.5	1.2	51.4	19.8	0.0	242.0
	SD	0.1	35.9	43.4	0.3	0.8	3.4	0.5	0.1	0.1	3.7	3.1	0.6	10.9	5.0	5.7	11.2	0.4	26.7	8.2	15.0	26.2
S-6	Avg	7.9	853.1	536.4	0.3	4.1	18.2	1.1	0.3	0.5	34.5	24.2	2.1	289.0	73.4	24.9	57.3	3.2	105.8	63.7	0.0	288.3
	Max	8.1	900.0	576.0	0.6	7.0	31.2	1.9	0.3	0.7	40.0	27.0	3.2	312.0	80.0	29.7	72.0	4.5	136.0	70.0	0.0	316.0
	Min	7.7	758.9	469.2	0.2	1.1	5.0	0.8	0.2	0.4	26.0	19.0	1.2	272.0	64.3	21.3	50.0	2.1	90.0	55.0	0.0	242.0
	SD	0.2	51.6	37.8	0.1	2.0	8.9	0.4	0.0	0.1	5.4	3.1	0.9	14.7	5.3	3.0	8.3	0.9	19.2	5.8	0.0	25.3
S-7	Avg	8.5	822.4	517.0	0.1	3.0	13.3	1.0	0.3	0.3	21.1	24.2	5.5	283.3	67.7	28.1	48.7	2.1	88.2	44.7	11.4	288.2
	Max	8.6	900.0	576.0	0.2	3.5	15.6	1.8	0.3	0.4	24.0	27.0	5.8	312.0	70.2	34.0	54.0	3.1	106.0	52.0	24.0	300.0

	Min	8.3	757.7	458.8	0.1	1.3	5.6	0.7	0.3	0.2	17.9	19.0	5.2	268.0	60.9	24.3	43.0	1.7	70.6	33.0	4.7	278.0
	SD	0.1	55.8	46.6	0.0	0.9	3.9	0.4	0.0	0.1	2.3	3.1	0.2	15.5	3.5	3.8	3.5	0.5	14.3	6.7	7.2	9.6
S-8	Avg	8.3	748.8	487.3	0.5	3.0	13.3	0.8	0.3	0.4	23.7	24.2	5.2	255.7	60.7	25.4	52.2	2.4	95.7	43.7	13.3	234.0
	Max	8.5	860.0	594.0	0.8	3.4	15.2	1.3	0.4	0.5	38.0	27.0	5.8	320.0	73.1	34.0	75.0	3.0	116.0	50.0	40.0	288.0
	Min	8.2	640.0	410.0	0.1	2.5	11.2	0.4	0.2	0.2	12.0	19.0	4.8	200.0	45.0	19.9	40.0	1.9	72.0	30.0	0.0	190.0
	SD	0.1	91.1	75.6	0.3	0.3	1.6	0.4	0.1	0.1	10.7	3.1	0.4	48.3	11.3	5.6	13.0	0.4	17.0	7.1	15.1	39.7
S-9	Avg	8.2	788.4	490.2	0.3	2.9	13.1	0.8	0.2	0.5	42.7	24.2	3.4	263.1	58.0	30.1	55.9	1.8	93.2	26.7	4.7	270.1
	Max	8.6	880.0	564.0	0.6	3.6	16.1	1.1	0.3	0.6	64.0	27.0	4.5	278.0	60.0	36.0	72.0	2.3	110.0	40.0	12.0	290.0
	Min	7.6	730.0	434.0	0.0	1.9	8.3	0.5	0.2	0.4	24.4	19.0	2.4	236.0	55.8	26.0	50.4	0.7	74.2	16.9	0.0	254.5
	SD	0.4	64.0	52.4	0.3	0.7	3.0	0.3	0.0	0.1	13.0	3.1	0.9	15.9	1.7	3.7	8.2	0.6	15.5	8.6	5.4	14.9
S-10	Avg	8.2	788.3	502.9	0.1	2.6	11.6	1.0	0.2	0.3	40.7	24.2	3.8	291.1	67.6	29.8	48.7	1.9	85.3	25.3	6.0	284.0
	Max	8.5	864.0	553.0	0.2	3.5	15.6	1.3	0.2	0.4	56.7	27.0	4.2	320.0	72.5	35.5	52.0	3.2	96.0	34.0	10.0	340.0
	Min	7.6	747.6	462.3	0.0	1.3	5.7	0.8	0.2	0.2	35.0	19.0	3.2	264.0	58.5	23.4	44.0	0.6	73.9	15.7	0.0	256.0
	SD	0.3	41.6	30.6	0.1	0.8	3.5	0.2	0.0	0.1	8.1	3.1	0.4	22.9	4.9	5.3	3.1	0.9	9.2	6.7	3.5	30.4
S-11	Avg	8.3	814.8	520.4	0.1	2.9	12.9	1.2	0.2	0.5	40.0	24.2	4.2	273.9	67.5	27.0	46.9	1.8	87.9	33.0	7.3	281.9
	Max	8.5	912.0	584.0	0.3	5.0	22.3	1.4	0.3	0.6	63.0	27.0	4.6	292.0	73.7	29.2	60.0	2.9	108.0	44.0	12.0	310.0
	Min	7.8	755.0	480.4	0.1	0.8	3.7	0.8	0.2	0.4	26.5	19.0	3.8	242.0	57.7	23.8	39.0	0.8	70.0	10.3	0.0	256.0
	SD	0.3	60.6	45.6	0.1	1.5	6.5	0.2	0.0	0.1	12.5	3.1	0.4	17.9	5.6	2.0	7.7	0.8	14.8	12.5	5.9	19.5
S-12	Avg	8.4	846.5	538.8	0.5	3.9	17.4	1.3	0.3	0.6	29.2	23.0	3.9	296.3	73.6	30.6	50.3	2.3	92.4	39.0	7.3	291.0
	Max	8.9	890.0	584.0	0.8	5.5	24.5	1.5	0.3	0.8	35.4	27.0	4.5	312.0	76.9	39.0	59.0	2.8	115.0	54.0	24.0	312.0
	Min	8.1	777.0	497.0	0.3	3.1	13.9	1.2	0.3	0.6	22.0	19.0	3.2	280.0	67.3	26.7	40.0	1.9	73.2	30.0	0.0	264.0
	SD	0.3	50.2	39.1	0.2	0.9	4.1	0.1	0.0	0.1	4.9	3.2	0.5	11.8	3.5	4.6	6.9	0.3	17.2	8.1	9.5	17.4
S-13	Avg	8.2	869.0	545.3	0.8	3.3	14.9	0.9	0.1	0.5	30.1	23.0	4.7	307.0	78.1	36.2	53.4	2.2	105.2	37.5	3.0	309.3
	Max	8.5	890.0	570.0	1.7	3.8	16.9	1.6	0.3	0.7	34.0	27.0	5.9	340.0	94.0	54.0	56.0	3.2	116.0	46.0	10.0	346.0
	Min	7.7	830.0	531.0	0.1	3.1	13.7	0.7	0.0	0.4	23.6	19.0	3.9	282.0	72.1	24.7	51.0	1.3	94.0	21.0	0.0	274.0
	SD	0.3	23.4	15.5	0.6	0.2	1.1	0.3	0.1	0.1	3.8	3.2	0.8	22.2	8.4	10.5	1.7	0.8	8.8	9.2	4.7	27.8

4.3 Water quality observation of Peizometer (purpose driven-wells)

General parameter

pH: The pH value ranged between 7.1 to 8.5. The highest value of 8.5 was recorded during the month of Oct-2011&Nov-2011 and lowest value of 7.1 was recorded in June-2012. The Maximum value 8.5 was recorded at Site PZ-03,PZ-12 and the Minimum value 7.1 was recorded at Site PZ-03.

Electrical Conductivity: Since the ions are the carries of electricity, the electrical conductivity of the water raises according to the content of soluble salts in the water. Generally E.C. defines as mobility of the ions. The value ranged between 300 to 1520 µs/cm. The Max value of 1520 µs/cm. was recorded in Feb-2012 and Min value of 300 µs/cm. was recorded Sep-2011.The Maximum value of 1520 µs/cm was recorded at Site PZ-2 and Minimum value of 400 µs/cm was recorded at Site PZ-10.

Total dissolved solids (TDS): Total dissolved solids are mainly the inorganic minerals and sometimes some organic matter. The TDS value ranged between 192 to 972 mg/l. the highest value of 972 mg/l was recorded Feb-2012 at site PZ-2 and lowest value of 192 mg/l was recorded at Sep-2011 at the site of PZ-10B.

POLLUTION INDICATING PARAMETER

NITRATE:-Nitrate is the important pollution indicating parameter. It is considered as important plant nutrient. Nitrate is the most oxidized or stable form of nitrogen. In Peizometer site the nitrate content of the water was in the range between 8.0 to 186.0mg/l. Maximum concentration 186.0mg/l of nitrate was found in site of PZ-10B Dec-2012 and minimum Nitrate 8.0 was observed at site PZ-10A Sep-2011.

T-PHOSPHATE: - In Peizometer site phosphate range observed between 0.1 to 0.42mg/l. Maximum T-phosphate 0.42mg/l was found at site PZ-03 in the month of Dec-2012and minimum phosphate 0.1 was found at all the site during the year 2011-2012.

CHEMICAL OXYGEN DEMAND: COD is an important parameter for knowing the quality of water, which analyzed by potassium dichromate open reflux method. High COD value may be due to presence of long chain of hydro-carbon for e.g. organic matter like amino acid, glucose.

In Peizometer site COD range observed between 0.0 to 42.0mg/l. Maximum COD 42.0mg/l was observed at site PZ-9A during the month of Sep-2011 which has untreated raw sewage

and minimum COD 0.0 was observed at site Pz-01, Pz-02 Sep&Oct-2011and Pz-10A, Pz-10B,Pz-12in the year of 2012.

AMMONIACAL NITROGEN: In a Peizometer range NH3-N range between 0.0 to 5.0 mg/l. Maximum NH3-N 5.0mg/l was observed at site Pz-10A during the month of Oct&Dec-2012 and minimum NH3-N 0.0mg/l was observed at site Pz-02 Oct-2012, Pz-10A Oct-2011and sep- 2011 at the site of Pz-12.

Fluoride: The fluoride value ranged between 0.0 to 0.7 mg/l. During the study period highest value was observed 0.7mg/l at site Pz-12.

Hardness

Total Hardness: The Total Hardness value ranged between 64 to 488 mg/l. During the study period the highest value of 488 mg/l was noted in Oct-2011 and lowest value of 64 mg/l was noted in Sep-2011. The maximum value of total hardness 488 mg/l was recorded at Site Pz-02 and while as minimum value of 64 mg/l was recorded at Site Pz-4.

Major ion

Calcium Ion (Ca^{++}):- The Calcium ion value was ranging between 9.6 to 105.0mg/l. The highest value of 105.0mg/l was noted in Dec-2012 and lowest value of 9.6mg/l was noted in Sep-2011. The maximum value of 105.0mg/l was recorded at site PZ-09A and minimum value of 9.6 mg/l was recorded at site PZ-09B.

Magnesium ion (Mg^{++}): The Magnesium ion value ranged between 6.8 to 61.2mg/l. The highest value of 61.2mg/l was recorded in Nov-2011 and lowest value of 6.8mg/l was recorded in Sep-2011. The Maximum value of 61.2 mg/l was recorded at Site Pz-02 and Minimum value of 6.8 mg/l was recorded at Site Pz-04.

Sodium (Na^{+}): The sodium value ranging between 20.0 to 107.0mg/l. The highest value of 107.0mg/l was recorded in Oct-2012 and lowest value of 20.0mg/l was recorded in Oct-2011. The Maximum value of 107.0 mg/l was recorded at Site Pz-02 and Minimum value of 20.0 mg/l was recorded at Site Pz-10A.

Potassium (k^{+}): The Potassium value ranging between 0.3 to7.6mg/l. The highest value of 7.6mg/l was recorded in Oct-2012 and lowest value of 0.3mg/l was recorded in Oct-2011 at site Pz-10B.The Maximum value of 7.6mg/l was recorded at Site Pz-12.

Chloride: The chloride value ranged between 38.0 to 176.0 mg/l. The highest value of 176.0 mg/l was noted in Nov-2012 at site Pz-02 and lowest value of 38.0 mg/l was noted in Oct-2011at site Pz-10A.

Sulphate : The sulphate value ranged between 1.0 to 69.0mg/l. The highest value of 69.0 mg/l was noted in Oct-2012 at site Pz-02 and lowest value of 1.0 mg/l was noted in Oct-2012 at site Pz-9B.

Carbonate(CO_3^-): The Carbonate value ranged between 0.0 to 12.0 mg/l. the highest value of 12.0 mg/l noted in Nov-2011 and April&June-2012at site Pz-02&Pz-01B,and the minimum value was recorded at all the site.

Bicarbonate (HCO_3^-):- Bicarbonate value ranged between 60.0to380mg/l. The highest value of 380mg/l was noted in Oct -2011 and lowest value of 60.0mg/l was noted in Sep-2011.The Maximum value of 380.0mg/l was recorded at Site Pz-02, and minimum value of 60.0mg/l was recorded at Site Pz-04.

General water quality parameters in Peizometers around Shahpura lake, Bhopal (MP)

Fig 39: Graphical presentation of pH in Shahpura Lake

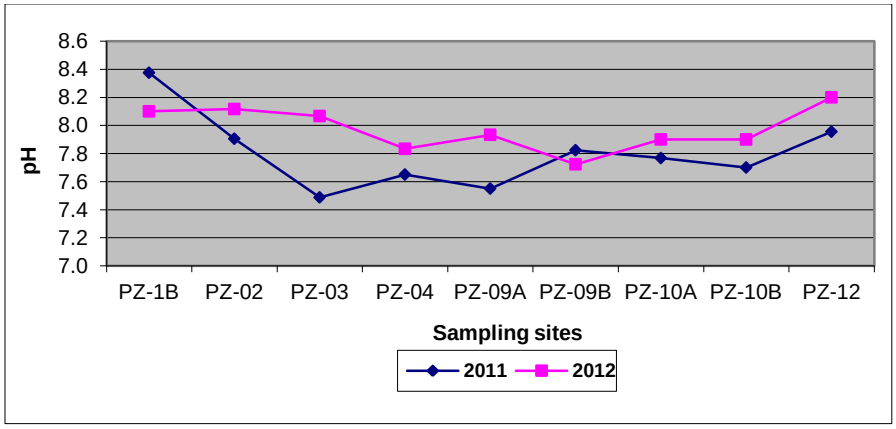


Fig 40: Graphical presentation of Conductivity in Shahpura lake

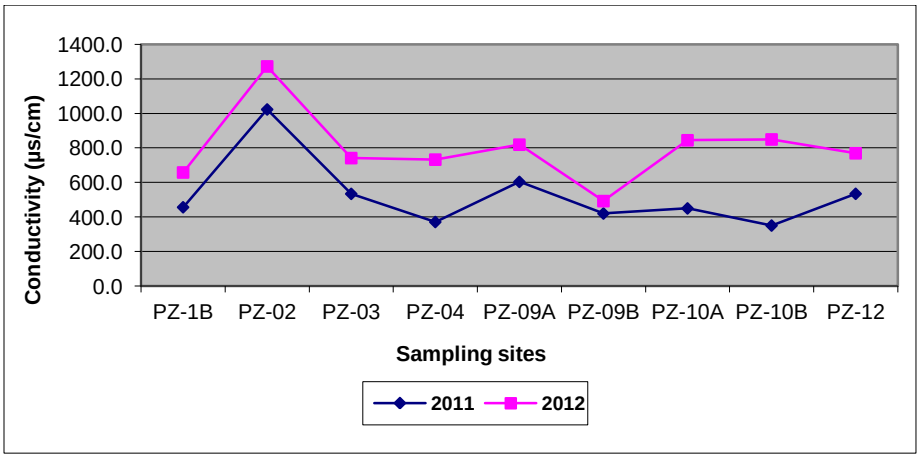
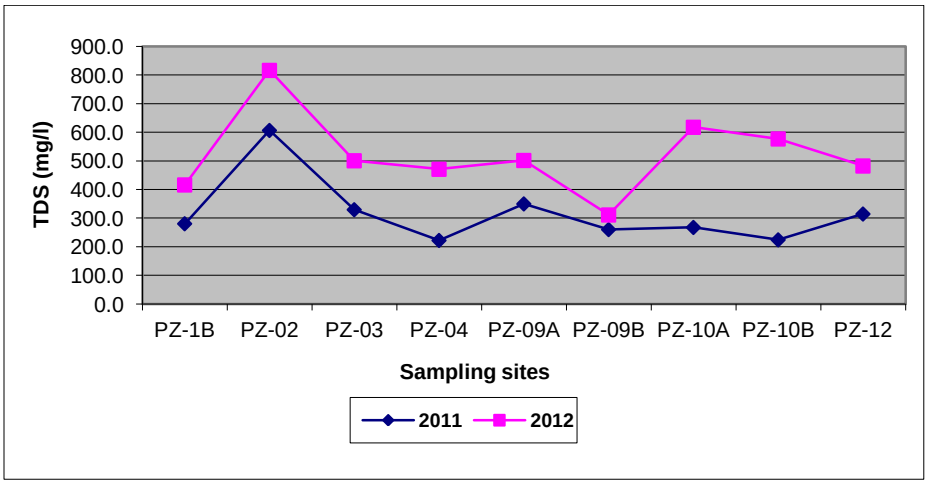


Fig 41: Graphical presentation of TDS in Shahpura Lake



Pollution indicating parameters in Peizometers around Shahpura lake, Bhopal

Fig 42: Graphical presentation of NH3-N in Shahpura Lake

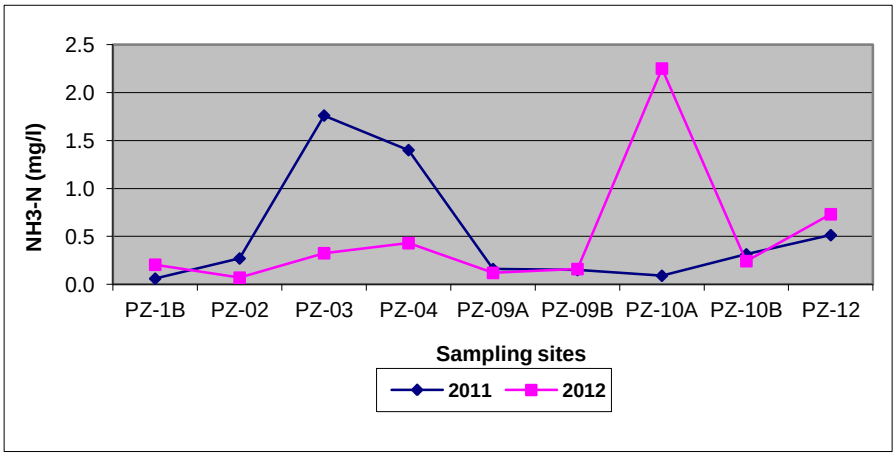


Fig 43: Graphical presentation of NO_2-NO_3 in Shahpura Lake

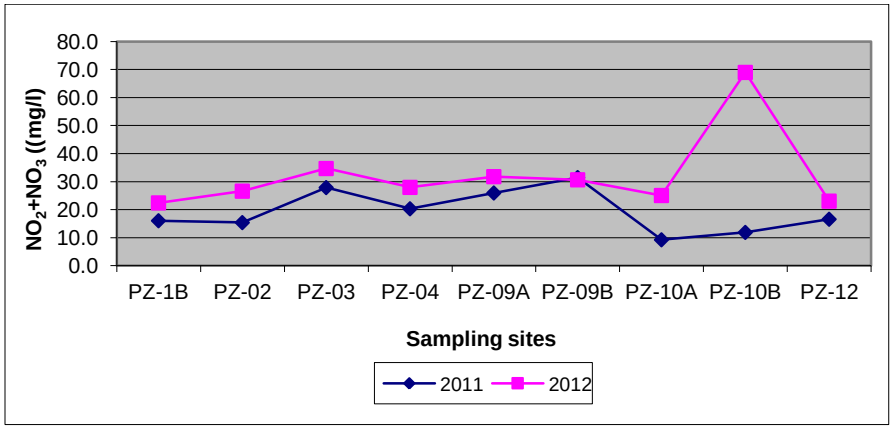


Fig 44: Graphical presentation of Tot. Phosphate in Shahpura Lake

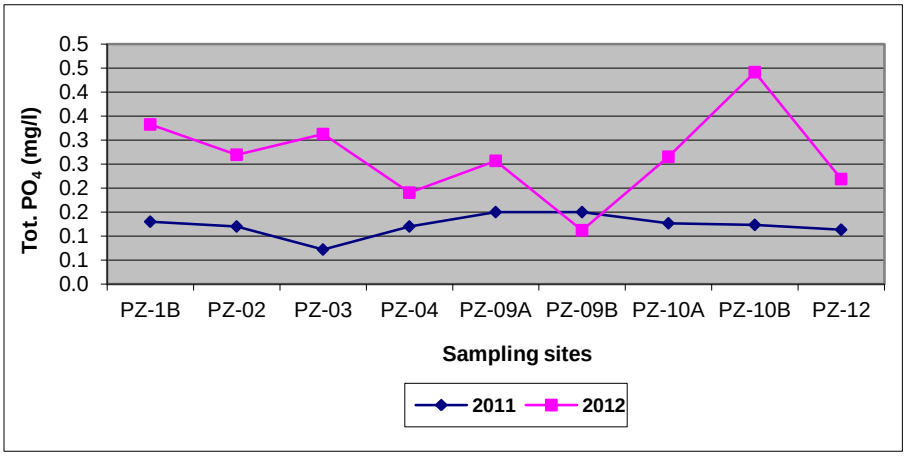


Fig 45: Graphical presentation of COD in Shahpura Lake

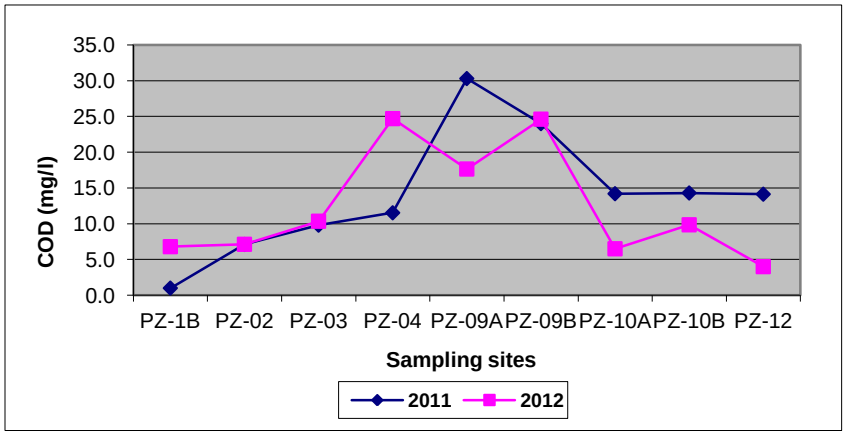


Fig 46: Graphical presentation of Tot. Hardness in Shahpura Lake

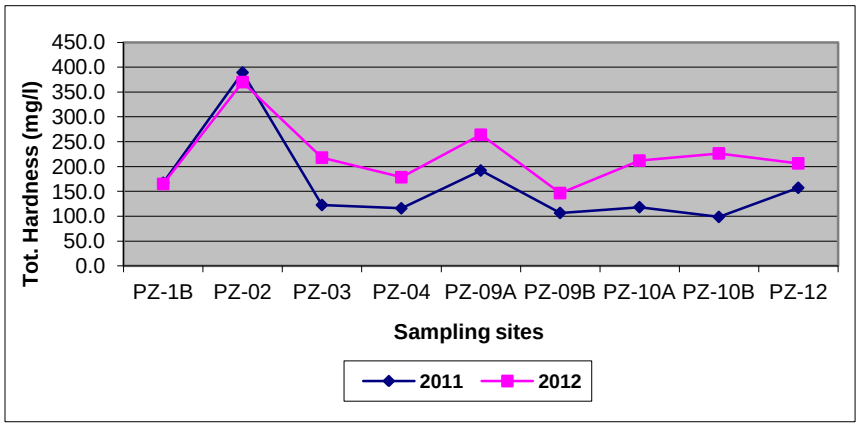


Fig 47: Graphical presentation of Ca Hardness in Shahpura Lake

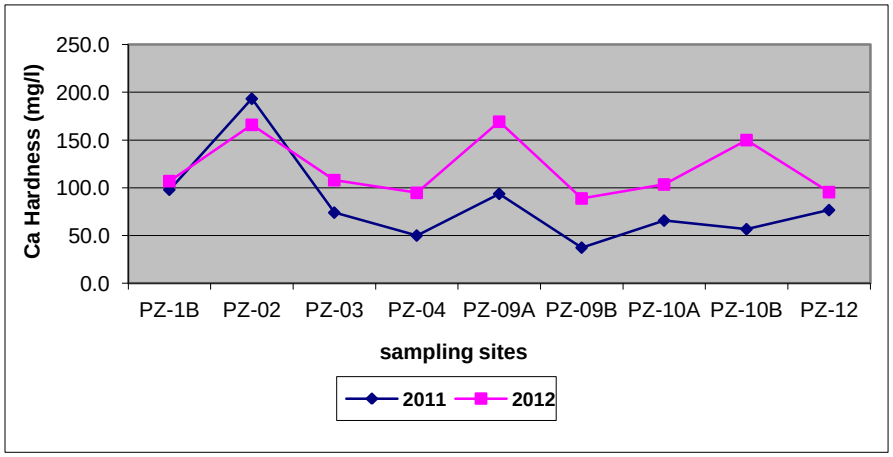


Fig 48: Graphical presentation of Mg ion in Shahpura Lake

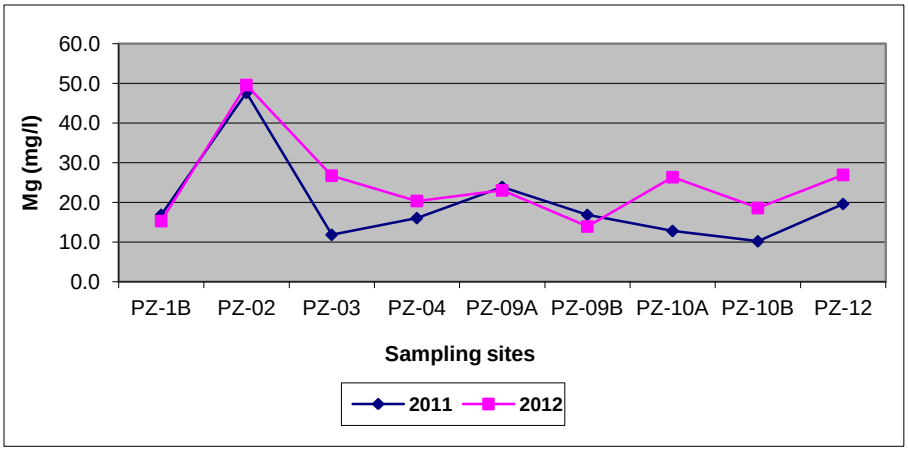


Fig 49: Graphical presentation of Na ion in Shahpura Lake

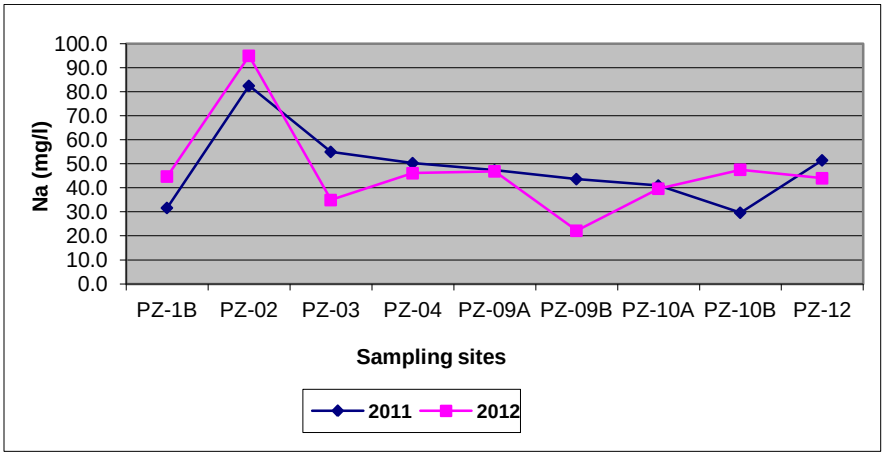


Fig 50: Graphical presentation of K ion in Shahpura Lake

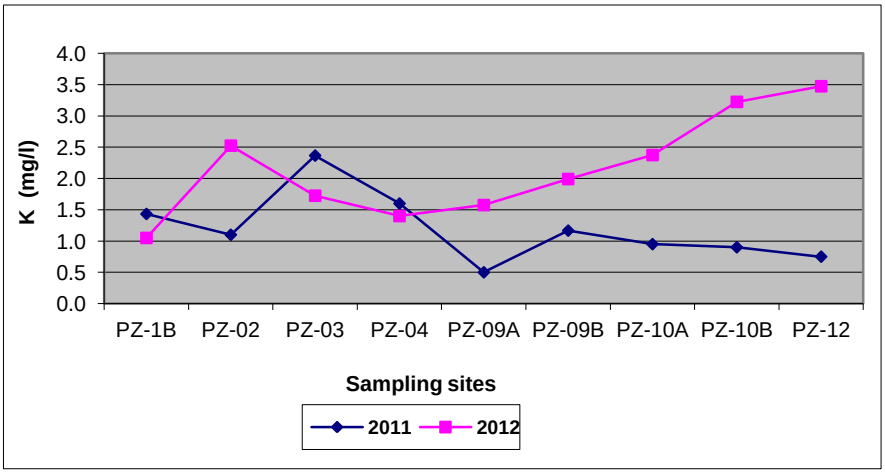


Fig 51: Graphical presentation of Chloride ion in Shahpura Lake

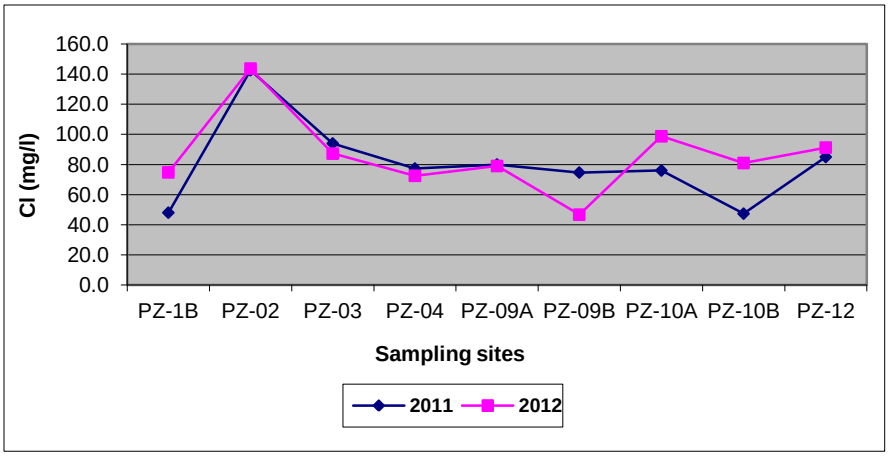


Fig 52: Graphical presentation of Sulphate ion in Shahpura Lake

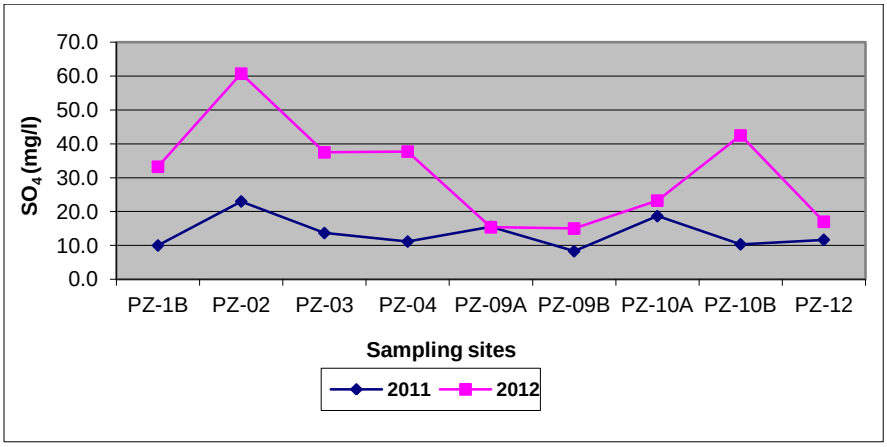


Fig 53: Graphical presentation of Fluoride in Shahpura Lake

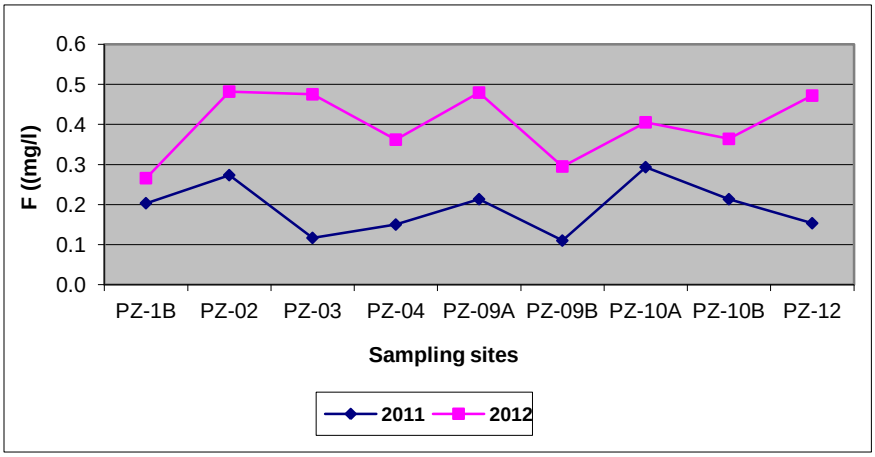


Fig 54: Graphical presentation of Tot. Alkalinity in Shahpura Lake

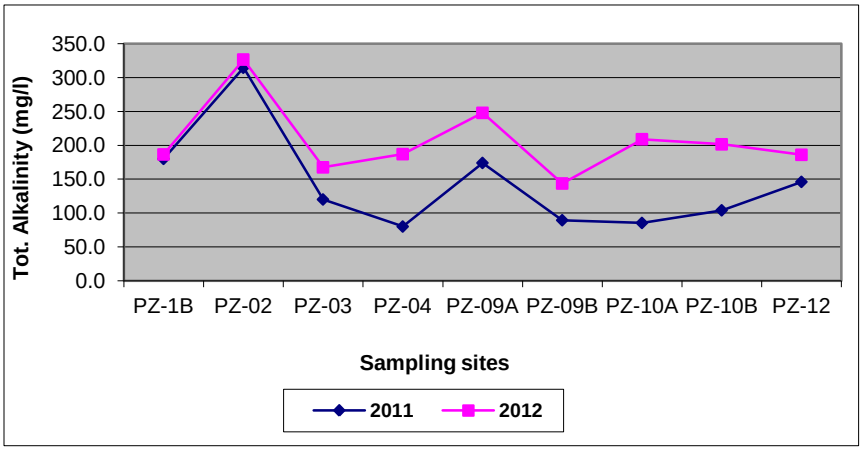


Table 8: Water quality observation of Peizometer (Year 2011)

2011		General			Nutrients				Hardness		Major Ions							Alkalinity	
	Parameters	pH	EC_GEN	TDS	NH3-N	NO2+NO3	p-T	COD	Har_T	Har_Ca	Ca	Mg	Na	K	Cl	SO4	F	Alk-P	Alk-TOT
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mgP/L	mg/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgCaCO3/L	mgCaCO3/L
PZ-1	Avg	8.1	456.7	280.7	0.1	3.6	0.1	1.0	167.3	98.0	39.3	16.8	31.7	1.4	48.0	10.0	0.2	3.3	180.0
	Min	7.6	415.0	245.0	0.1	3.1	0.1	0.0	154.0	86.0	34.5	16.5	29.0	0.6	44.0	9.0	0.2	0.0	164.0
	Max	8.4	525.0	336.0	0.1	4.0	0.2	2.0	184.0	112.0	44.9	17.5	36.0	1.9	52.0	11.0	0.2	8.0	196.0
	SD	0.4	59.7	48.6	0.0	0.5	0.1	1.0	15.3	13.1	5.3	0.6	3.8	0.7	4.0	1.0	0.0	4.2	16.0
PZ-2	Avg	8.1	1023.3	606.7	0.2	3.5	0.1	7.1	389.3	193.3	77.5	47.6	82.5	1.1	142.7	23.0	0.3	5.3	314.7
	Min	7.6	900.0	526.0	0.1	2.7	0.1	4.7	280.0	140.0	56.1	34.0	75.0	0.7	120.0	16.0	0.0	0.0	236.0
	Max	8.4	1180.0	661.0	0.4	5.1	0.2	8.6	448.0	252.0	101.0	61.2	90.0	1.5	176.0	29.0	0.4	12.0	380.0
	SD	0.4	142.9	71.2	0.2	1.4	0.0	2.1	94.8	56.2	22.5	13.6	10.6	0.6	29.5	6.6	0.2	6.1	72.9
PZ-3	Avg	8.1	534.3	329.7	1.4	2.7	0.1	3.3	122.7	74.0	29.7	11.8	55.0	2.4	94.0	13.7	0.1	2.7	120.0
	Min	7.7	470.0	284.0	0.1	1.3	0.0	1.0	96.0	52.0	20.8	10.2	50.0	0.9	80.0	6.0	0.0	0.0	102.0
	Max	8.5	624.0	399.0	2.3	5.4	0.2	7.9	152.0	92.0	36.9	14.6	61.0	4.1	114.0	18.0	0.3	4.0	140.0
	SD	0.4	80.1	61.0	1.2	2.4	0.1	4.0	28.1	20.3	8.1	2.4	5.6	1.6	17.8	6.7	0.2	2.3	19.1
PZ-4	Avg	7.8	371.3	222.3	0.7	2.2	0.1	4.9	116.0	50.0	20.0	16.0	50.3	1.6	77.3	11.2	0.2	0.0	80.0
	Min	7.7	320.0	180.0	0.1	0.9	0.1	1.0	64.0	34.0	13.6	6.8	40.0	0.6	60.0	9.5	0.0	0.0	60.0
	Max	7.9	452.0	289.0	2.0	5.0	0.2	12.6	212.0	80.0	32.1	32.1	69.0	3.5	106.0	12.0	0.4	0.0	116.0
	SD	0.1	70.7	58.4	1.1	2.4	0.0	6.7	83.2	26.0	10.4	13.9	16.2	1.6	25.0	1.4	0.2	0.0	31.2
PZ-5	Avg	7.9	603.7	349.9	0.1	3.9	0.2	20.3	192.0	93.7	37.5	23.9	47.3	0.5	80.0	15.5	0.2	2.7	174.0
	Min	7.4	505.0	283.0	0.0	1.9	0.1	12.0	136.0	60.0	24.0	17.0	44.0	0.4	74.0	2.5	0.1	0.0	112.0
	Max	8.4	781.0	430.8	0.1	7.5	0.2	32.0	298.0	155.0	62.1	34.7	50.0	0.6	86.0	23.0	0.5	4.0	286.0
	SD	0.5	153.9	74.9	0.1	3.2	0.1	10.4	91.8	53.2	21.3	9.5	3.1	0.1	6.0	11.3	0.2	2.3	97.2
PZ-6	Avg	7.7	420.3	260.3	0.1	3.4	0.2	10.7	106.7	37.3	15.0	16.8	43.7	1.2	74.7	8.3	0.1	0.0	89.3
	Min	7.5	384.0	226.0	0.1	0.0	0.1	1.0	96.0	24.0	9.6	13.6	32.0	0.7	64.0	1.9	0.0	0.0	84.0
	Max	8.0	454.0	284.0	0.1	8.4	0.2	24.0	112.0	48.0	19.2	21.4	55.0	2.0	92.0	12.0	0.2	0.0	96.0
	SD	0.3	35.1	30.4	0.0	4.4	0.1	11.9	9.2	12.2	4.9	4.0	11.5	0.7	15.1	5.6	0.1	0.0	6.1
PZ-7	Avg	7.9	450.0	267.7	0.1	2.1	0.1	14.2	118.3	65.7	26.3	12.8	41.0	1.0	76.0	18.7	0.3	1.3	85.3
	Min	7.9	345.0	197.0	0.0	1.8	0.1	10.2	90.0	51.0	20.4	9.5	20.0	0.7	38.0	17.0	0.3	0.0	68.0
	Max	7.9	550.0	352.0	0.2	2.3	0.2	17.2	140.0	94.0	37.7	17.7	62.0	1.2	100.0	21.0	0.3	4.0	116.0
	SD	0.0	102.6	78.4	0.1	0.3	0.0	3.6	25.7	24.5	9.8	4.4	29.7	0.4	33.3	2.1	0.0	2.3	26.6

2011		General			Nutrients				Hardness		Major Ions							Alkalinity	
	Parameters	pH	EC_GEN	TDS	NH3-N	NO2+NO3	p-T	COD	Har_T	Har_Ca	Ca	Mg	Na	K	Cl	SO4	F	Alk-P	Alk-TOT
	Unit		µmho/cm	mg/L	mg N/L	mg N/L	mgP/L	mg/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgCaCO3/L	mgCaCO3/L
PZ-8	Avg	7.9	350.7	224.3	0.3	2.7	0.1	14.3	98.7	56.7	22.7	10.2	29.7	0.9	47.3	10.3	0.2	0.0	104.0
	Min	7.9	300.0	192.0	0.1	2.7	0.1	10.2	88.0	50.0	20.0	9.2	28.0	0.3	42.0	8.0	0.2	0.0	98.0
	Max	7.9	440.0	281.0	0.8	2.7	0.2	16.9	112.0	64.0	25.6	11.7	31.0	2.0	54.0	12.0	0.2	0.0	112.0
	SD	0.0	77.6	49.2	0.4	0.0	0.0	3.6	12.2	7.0	2.8	1.3	1.5	1.0	6.1	2.1	0.0	0.0	7.2
PZ-9	Avg	8.2	534.7	314.7	0.5	3.7	0.1	14.1	157.3	76.7	30.7	19.6	51.5	0.8	85.0	11.7	0.2	4.0	146.0
	Min	7.7	481.0	266.0	0.0	3.5	0.1	11.0	142.0	76.0	30.5	16.0	48.0	0.6	76.0	11.0	0.1	0.0	132.0
	Max	8.5	570.0	364.0	1.0	4.0	0.1	17.2	170.0	78.0	31.3	22.4	55.0	0.9	95.0	12.0	0.2	8.0	154.0
	SD	0.4	47.2	49.0	0.5	0.3	0.0	3.1	14.2	1.2	0.5	3.2	4.9	0.2	9.5	0.6	0.0	4.0	12.2

Table 9: Water quality observation of Peizometer (Year 2012)

2012		General			Nutrients				Hardness		Major Ions						ther Inorgani	Alkalinity	
	Parameters	pH_GEN	EC_GEN	TDS	NH3-N	NO2+NO3	p-TOT	COD	Har_Total	Har_Ca	Ca	Mg	Na	K	Cl	SO4	F	Alk-Phen	Alk-TOT
Sites	Unit	pH units	µmho/cm	mg/L	mg N/L	mg N/L	mgP/L	mg/L	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgCaCO3/L	mgCaCO3/L
PZ-1	Avg	8.4	658.3	416.3	0.2	5.1	0.3	6.8	165.0	107.0	42.9	15.3	44.8	1.1	74.8	33.3	0.3	8.0	186.5
	Min	8.3	643.0	400.0	0.2	4.2	0.3	5.0	144.0	96.0	38.5	10.7	41.0	0.6	56.0	25.0	0.2	0.0	172.0
	Max	8.4	695.0	444.0	0.3	6.2	0.4	8.0	188.0	116.0	46.5	17.4	50.0	1.3	92.0	45.0	0.3	12.0	200.0
	SD	0.1	24.7	19.2	0.0	0.9	0.0	1.3	19.1	8.9	3.6	3.1	3.9	0.3	15.0	8.7	0.0	5.7	12.2
PZ-2	Avg	7.9	1272.5	816.5	0.1	6.0	0.3	7.1	370.0	166.0	66.5	49.6	95.0	2.5	143.8	60.8	0.5	0.0	326.8
	Min	7.5	1020.0	652.0	0.0	4.4	0.2	0.0	300.0	100.0	40.0	44.7	75.0	1.4	126.0	50.0	0.3	0.0	272.0
	Max	8.2	1520.0	972.0	0.1	9.3	0.3	14.8	400.0	200.0	80.2	55.4	107.0	3.6	159.0	69.0	0.6	0.0	365.0
	SD	0.3	205.2	130.9	0.0	2.2	0.0	6.1	47.2	45.5	18.3	4.4	13.9	0.9	13.8	8.1	0.1	0.0	40.2
PZ-3	Avg	7.5	741.5	500.8	0.2	7.9	0.3	3.6	218.0	108.0	49.3	26.7	35.0	1.7	87.3	37.5	0.5	0.0	167.5
	Min	7.3	562.0	418.0	0.1	6.6	0.2	0.0	180.0	60.0	45.7	23.8	28.8	1.5	78.0	17.0	0.3	0.0	144.0
	Max	7.7	880.0	563.0	0.3	8.9	0.4	5.9	252.0	132.0	52.9	29.2	38.0	2.1	94.0	49.0	0.6	0.0	184.0
	SD	0.2	132.2	60.5	0.1	1.0	0.1	2.5	30.2	32.9	3.1	2.8	4.3	0.3	7.3	14.3	0.1	0.0	17.8
PZ-4	Avg	7.7	732.5	471.0	0.0	6.3	0.2	9.8	178.5	94.8	38.0	20.4	46.1	1.4	72.5	37.8	0.4	0.0	187.0
	Min	7.4	499.0	320.0	0.0	5.9	0.1	0.0	128.0	60.0	24.0	16.5	35.0	1.1	68.0	29.0	0.3	0.0	124.0
	Max	7.8	902.0	577.0	0.1	6.6	0.3	29.6	204.0	115.0	46.1	24.3	56.5	1.7	78.0	47.0	0.4	0.0	218.0
	SD	0.2	168.6	108.3	0.0	0.4	0.1	13.4	34.7	24.2	9.7	4.3	8.9	0.3	4.4	7.9	0.1	0.0	42.6
PZ-5	Avg	7.6	819.3	501.8	0.0	6.7	0.3	15.4	264.0	169.3	67.6	23.0	46.9	1.6	79.0	15.4	0.5	0.0	248.0
	Min	7.2	712.0	418.0	0.0	5.1	0.2	11.0	218.0	121.0	48.5	18.0	39.6	1.3	64.0	2.5	0.3	0.0	206.0
	Max	7.9	916.0	586.0	0.1	8.9	0.3	22.2	380.0	264.0	105.0	28.2	53.0	2.1	96.0	25.0	0.6	0.0	360.0
	SD	0.3	107.3	93.9	0.0	1.6	0.0	4.9	77.5	64.8	25.6	4.2	5.9	0.4	14.0	9.9	0.1	0.0	74.8
PZ-6	Avg	7.8	492.3	311.3	0.1	3.9	0.1	9.6	146.7	88.8	35.6	13.9	22.2	2.0	46.7	15.0	0.3	0.0	143.6
	Min	7.7	451.3	273.3	0.1	1.5	0.1	6.3	106.7	61.3	24.6	11.0	20.7	1.1	44.0	1.0	0.0	0.0	97.3
	Max	7.9	600.0	384.0	0.1	6.2	0.1	11.2	200.0	144.0	57.7	18.5	24.0	3.1	50.0	23.0	0.4	0.0	212.0
	SD	0.1	72.0	50.8	0.0	2.2	0.0	2.3	40.5	37.4	15.0	3.2	1.6	1.0	2.5	10.2	0.2	0.0	49.1
PZ-7	Avg	7.8	844.8	617.8	2.3	5.7	0.3	6.5	212.0	103.5	41.5	26.4	39.7	2.4	98.8	23.3	0.4	0.0	209.0
	Min	7.4	754.0	570.0	0.1	5.0	0.2	0.0	176.0	84.0	33.7	20.9	22.7	1.5	92.0	15.0	0.3	0.0	168.0
	Max	8.0	961.0	652.0	3.1	6.2	0.3	13.0	292.0	128.0	51.2	39.8	47.0	2.9	106.0	35.0	0.5	0.0	300.0
	SD	0.3	98.0	35.2	1.5	0.6	0.0	6.5	54.0	18.4	7.3	9.0	11.4	0.6	6.4	8.7	0.1	0.0	61.3
PZ-8	Avg	7.7	849.5	577.0	0.2	15.6	0.4	9.9	226.5	150.0	60.1	18.6	47.6	3.2	81.0	42.5	0.4	0.0	201.5
	Min	7.1	756.0	560.0	0.1	6.1	0.3	0.0	152.0	96.0	38.5	12.6	45.0	2.1	54.0	40.0	0.3	0.0	134.0
	Max	8.0	948.0	606.0	0.3	42.3	0.5	17.4	420.0	280.0	112.0	34.0	50.0	5.0	102.0	45.0	0.5	0.0	372.0
	SD	0.4	91.2	20.8	0.1	17.8	0.1	7.3	129.3	87.1	34.8	10.3	2.1	1.2	22.2	2.1	0.1	0.0	114.0
PZ-9	Avg	8.0	769.5	482.5	0.7	5.2	0.2	4.0	206.5	95.5	42.3	26.9	44.0	3.5	91.3	17.0	0.5	0.0	186.0
	Min	7.7	666.0	426.0	0.4	3.1	0.2	0.0	198.0	80.0	40.1	23.8	40.0	1.8	78.0	12.0	0.3	0.0	168.0
	Max	8.1	943.0	603.0	1.2	6.2	0.3	8.0	224.0	102.0	48.1	30.1	47.1	7.6	100.0	23.0	0.7	0.0	204.0
	SD	0.2	120.4	81.3	0.3	1.5	0.0	4.6	11.9	10.4	3.9	3.1	3.0	2.8	10.8	5.8	0.2	0.0	14.7

4.4 Water quality observation of Baseline (Ground water)

General parameter

pH: The pH value ranged between 7.0 to 8.7. The highest value of 8.7 was recorded during the month of Oct- 2011 and lowest value of 7.0 was recorded in June- 2012. The Maximum value 8.7 was recorded at Site G-9 and the Minimum value 7.0 was recorded at similar Site G-9 during the period of june-2012.

Electrical Conductivity: Since the ions are the carriers of electricity, the electrical conductivity of the water rises according to the content of soluble salts in the water. Generally E.C. is defined as mobility of the ions. The value ranged between 410 to 1520 µs/cm. The Maximum value of 1520 µs/cm. was recorded in Oct- 2012 and Min value of 410 µs/cm. was recorded April-2010 in the Baseline area. The Maximum value of 1520 µs/cm was recorded at Site G-12B and Minimum value of 410µs/cm was recorded at Site G -7B.

Total dissolved solids (TDS): Total dissolved solids are mainly the inorganic minerals and sometimes some organic matter. The TDS value ranged between 262 to 972 mg/l. the highest value of 972 mg/l was recorded Oct-2012 at site G-12B and lowest value of 262 mg/l was recorded at April-2010 at the site of G-7B.

POLLUTION INDICATING PARAMETER

NITRATE:- Nitrate (NO3) is a naturally occurring form of nitrogen found in soil. Nitrogen is essential to all life. Most crop plants require large quantities to sustain high yields Nitrate can be expressed as either NO3 (nitrate) or NO3-N (nitrate-nitrogen). Nitrate levels above the EPA Maximum Contaminant Level of 10mg/l NO3- N or 45 mg/l NO3 may cause methemoglobinemia in infants. Nitrate (NO3) is a naturally occurring form of nitrogen found in soil. nitrate also can leach into groundwater. If people or animals drink water high in nitrate, it may cause methemoglobinemia, an illness found especially in infant, but sometimes rain or irrigation water can leach them into groundwater. Although nitrate occurs naturally in some groundwater, in most cases higher levels are thought to result from human activities. Common sources of nitrate include: fertilizers and manure, animal feedlots, municipal wastewater and sludge.

In Ground water the nitrate content of the water was in the range between 0.4 to 109.2mg/l. Maximum concentration 109.2mg/l of nitrate was found in site of G-11B oct-2012 and minimum Nitrate 0.4 -was observed at site G-7A during the month of Oct, Nov and Dec -2010 post-monsoon season.

PHOSPHATE: In Baseline area Phosphate range observed 0.0 to 1.0mg/l. **Max:-**T-phosphate 1.0mg/l was found at site G-11A in the month of Nov-2011

HEMICAL OXYGEN DEMAND:-The chemical oxygen demand observed ranging between 0.0 to 64 mg/l. Max COD 64.0mg/l was observed at site G-11A during the month of June-2010 and Min COD 0.0mg/l was observed at site G-5&G-12 june-2010.

Iron:-The Iron value observed ranging between 0.0 to 0.9mg/l. **Max** The Highest value 0.9mg/l was observed at site G-04&G-11A during the month of oct-2012. The Lowest value 0.0mg/l was observed at many site G-01-in this site of Feb&March-2011,similaraly it was observed G-4 Nov-2011,G-10 Feb&Dec-2011,G-10 April-2012,G-11A Jan&Feb-2011,G-11C Jan,Feb,March,Nov-2011 and G11C June-12.

Fluoride: The fluoride value ranged between 0.0 to 1.0 mg/l. During the study period highest value was observed 1.0mg/l at site G-01Jan-2011,G-05June-2011,G-09 Oct-2010&April-2011,G-10April,may,june-2010andJune-2011,G-11A April,may-2010,G-11C April,May,june-2010,G-12C April,June-2010,and G-13May-2011.

Total Hardness: The Total Hardness value ranged between 104 to 700 mg/l. During the study period the highest value of 700 mg/l was noted in June- 2012 and lowest value of 104 mg/l was noted in Oct-2012. The maximum value of total hardness 700 mg/l was recorded at Site G-12B and while as minimum value of 104 mg/l was recorded at Site G-02 in the Baseline area.

Calcium Ion (Ca^{++}):- The Calcium ion value was ranging between 32.0 to 165.6mg/l. The highest value of 165.6mg/l was noted in Nov-2010 and lowest value of 32.0mg/l was noted in Oct-2012. The maximum value of 165.6mg/l was recorded at site G-12B and minimum value of 32.0 mg/l was recorded at site G-02.

Magnesium ion(Mg^{++}): The Magnesium ion value ranged between 5.8 to 62.3mg/l. The highest value of 62.3mg/l was recorded in Oct-2012 and lowest value of 5.8mg/l was recorded in Oct-2011. The Maximum value of 62.3 mg/l was recorded at Site G-10 and Minimum value of 5.8 mg/l was recorded at Site G-02.

Sodium (Na^{+}): The sodium value ranging between 12.0 to 132.0mg/l. The highest value of 132.0mg/l was recorded in Dec-2010 and lowest value of 12.0mg/l was recorded in Oct-2012. The Maximum value of 132.0 mg/l was recorded at Site G-12B and Minimum value of 12.0 mg/l was recorded at Site G-2.

Potassium(k^{+}): The Potassium value ranging between 0.1 to 18.0mg/l. The highest value of 18.0mg/l was recorded in June-2010 and lowest value of 0.1mg/l was recorded in May-2011in

G-03,April-2012in G-05,May&june-2011in G-7B,May-2011in G-12C, and May-2011 in G-13. The Maximum value of 18.0 mg/l was recorded at Site G-13.

Chloride: The chloride value ranged between 32 to 248 mg/l. The highest value of 248 mg/l was noted in June-2012 at site G- 12B and lowest value of 42 mg/l was noted in April-2010,andApril,May-2011 at site G-7B.

Sulphate: The sulphate value ranged between 10.0 to144.0 mg/l. The highest value of 144.0 mg/l was noted in Oct-2012 at site G-05 and lowest value of 10.0 mg/l was noted in April-2011 at site G-12 in the Baseline area.

Carbonate(CO_3^-): The Carbonate value ranged between 0.0 to 25.2 mg/l. the highest value of 25.2 mg/l noted in Nov-2010 maximum value of carbonate 25.2 mg/l was recorded at Site G-10.

Bicarbonate(HCO_3^-):- Bicarbonate value ranged between 84.0 to 536.8 mg/l. The highest value of 536.8mg/l was noted in April -2010 and lowest value of 84mg/l was noted in Oct-2012.The Maximum value of 536.8 mg/l was recorded at Site G-11A, and minimum value of 84.0 mg/l was recorded at Site G-02.

Fig 55: Graphical presentation of pH in ground water.

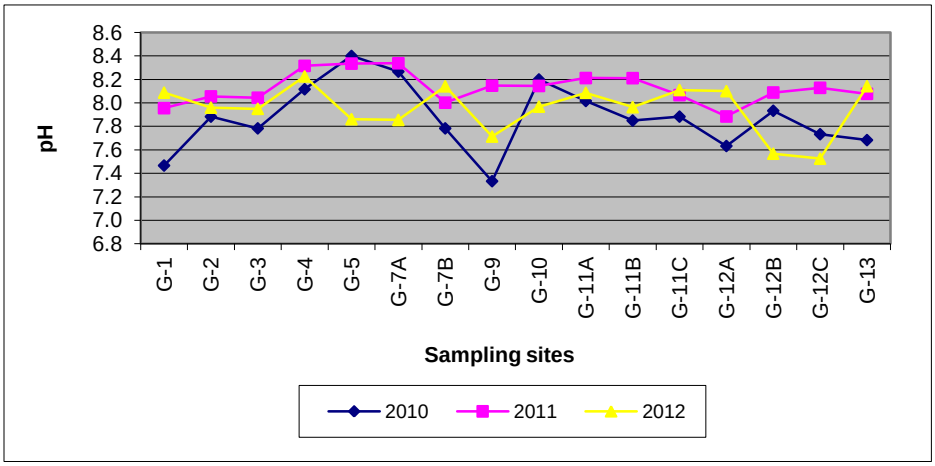


Fig 56: Graphical presentation of EC in ground water.

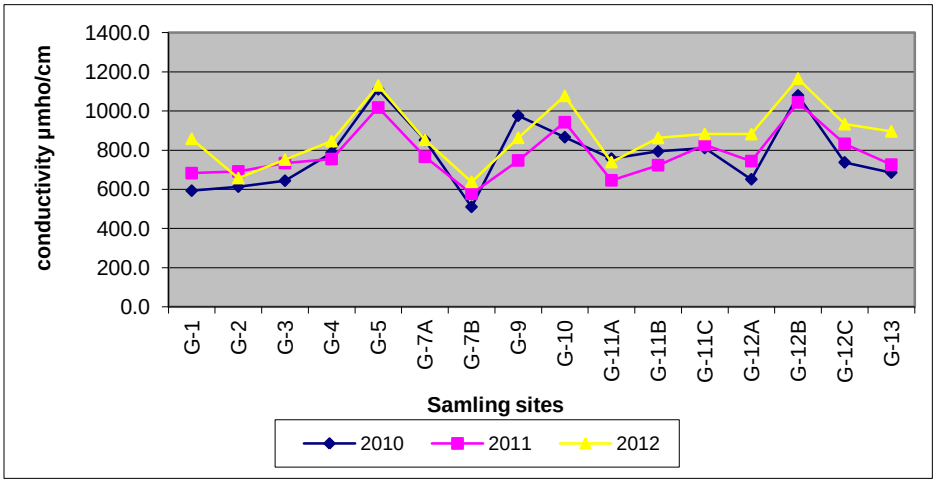


Fig 57: Graphical presentation of TDS in ground water.

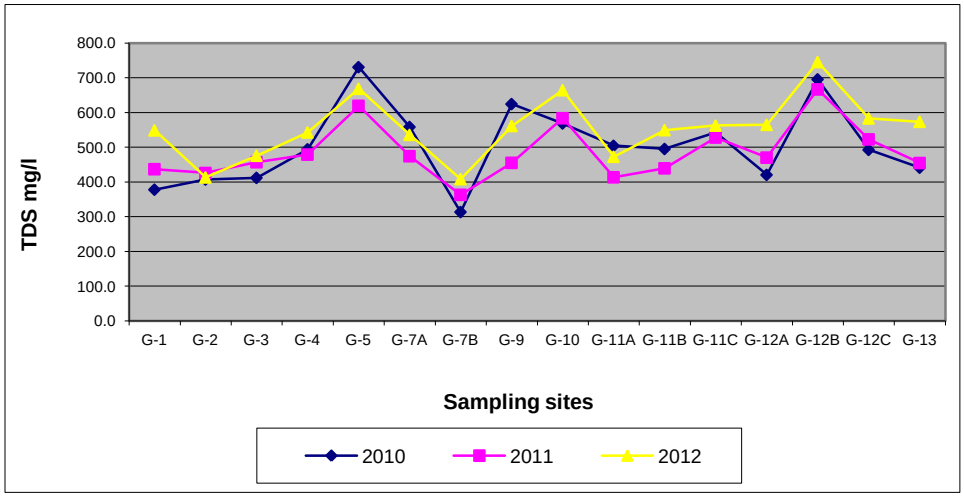


Fig 58: Graphical presentation of NO3 in ground water

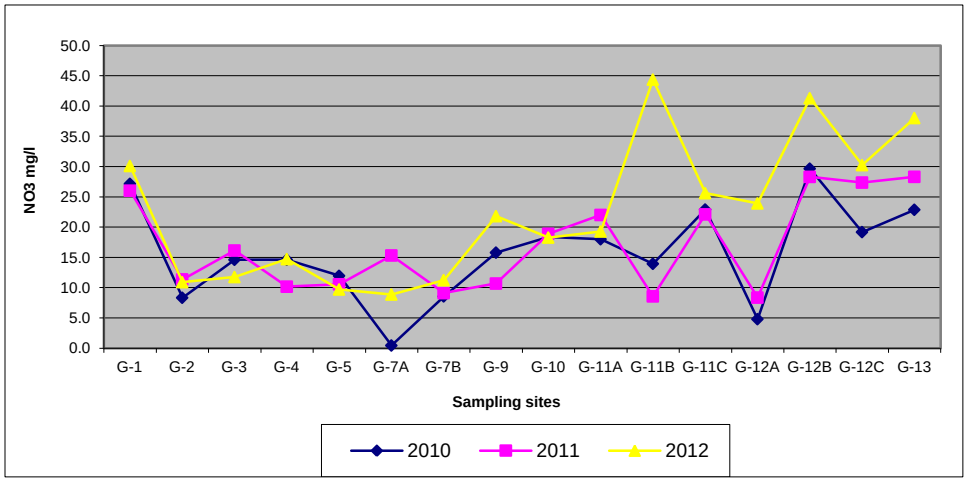


Fig 59: Graphical presentation of T.PO4 in ground water.

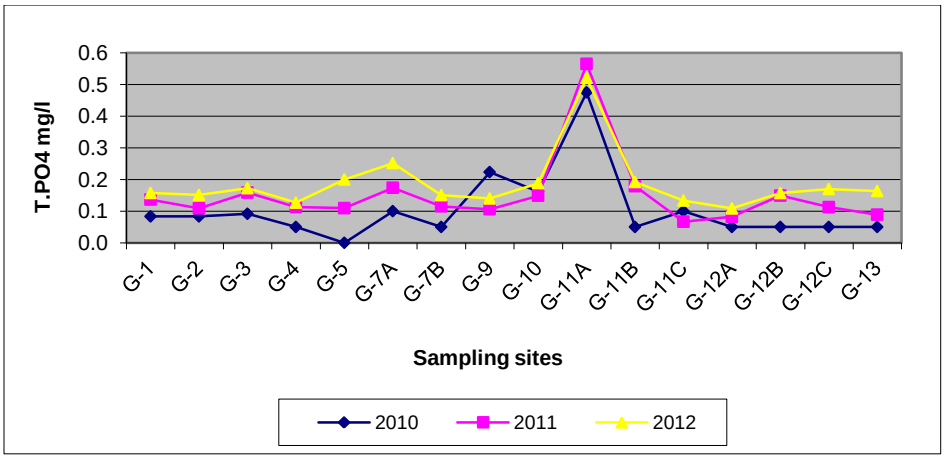


Fig 60: Graphical presentation of Iron in ground water .

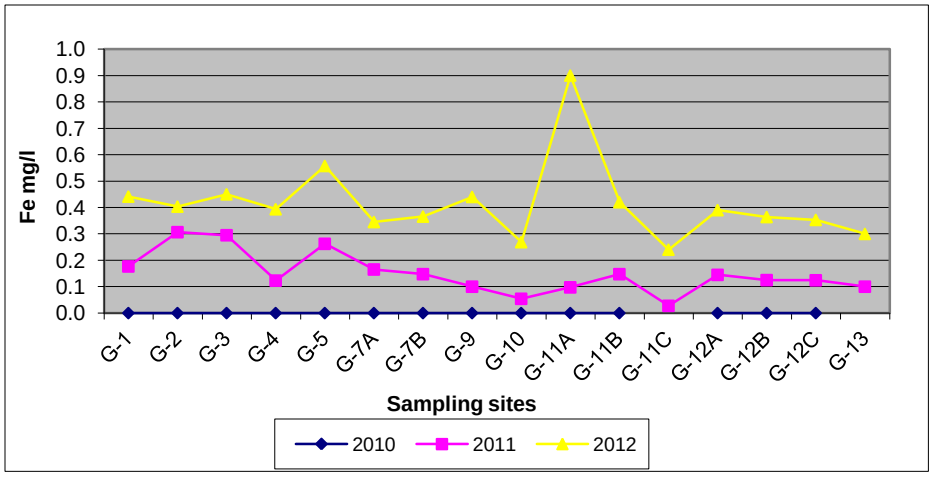


Fig 61: Graphical presentation of fluoride in ground water.

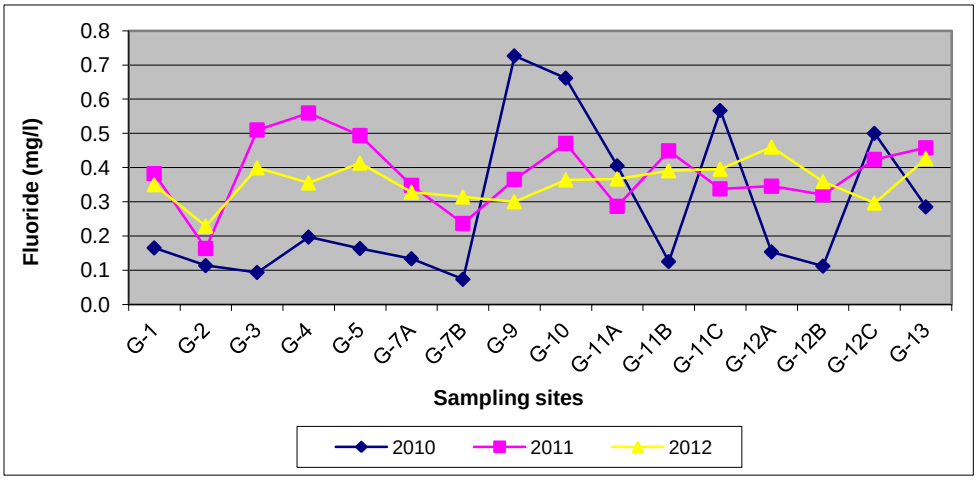


Fig 62: Graphical presentation of COD in ground water.

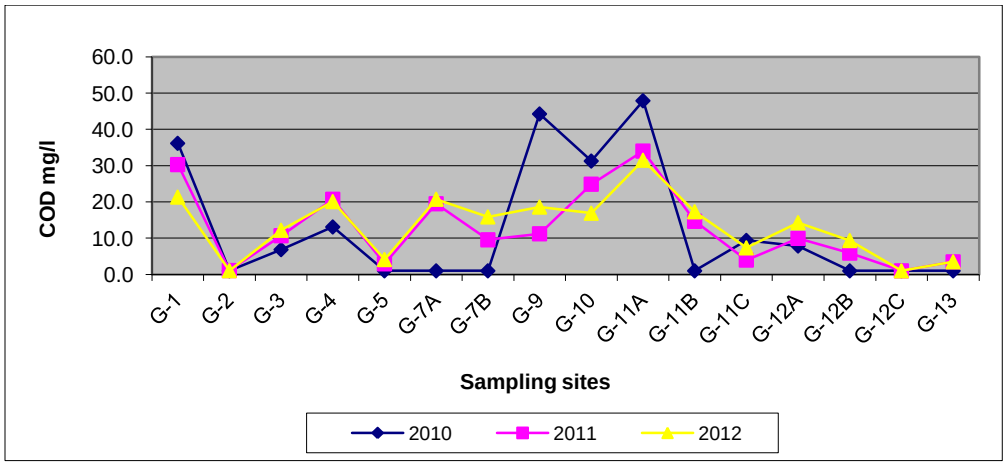


Fig 63: Graphical presentation of Tot. Hardness in ground water.

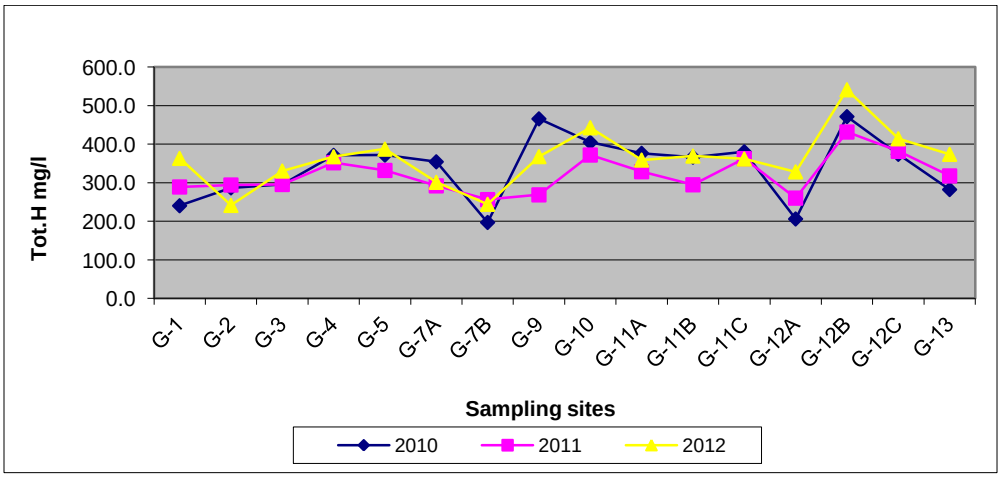


Fig 64: Graphical presentation of Ca- ion in ground water .

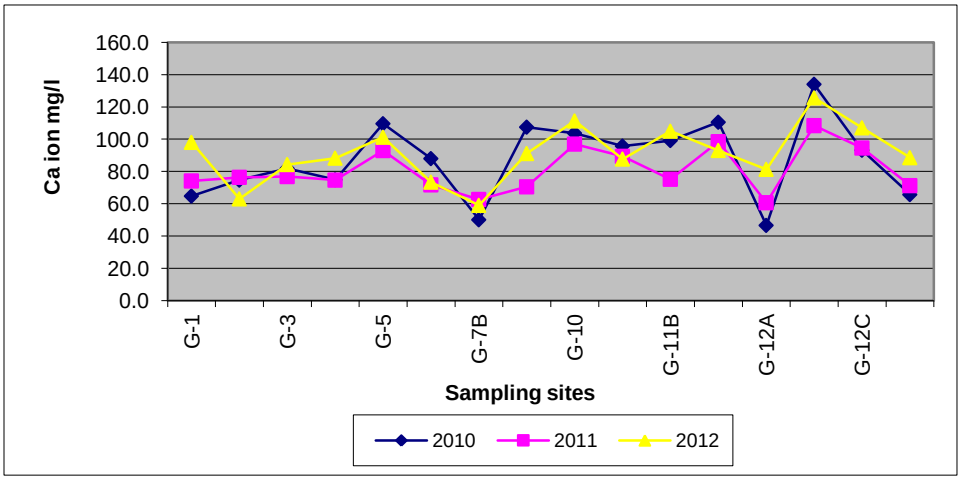


Fig 65: Graphical presentation of Mg-ion in ground water

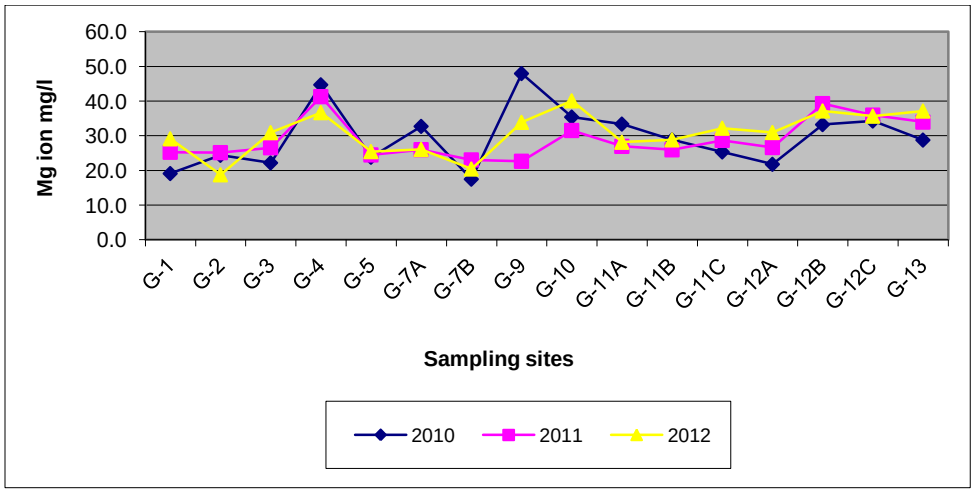


Fig 66: Graphical presentation of Sodium in ground water

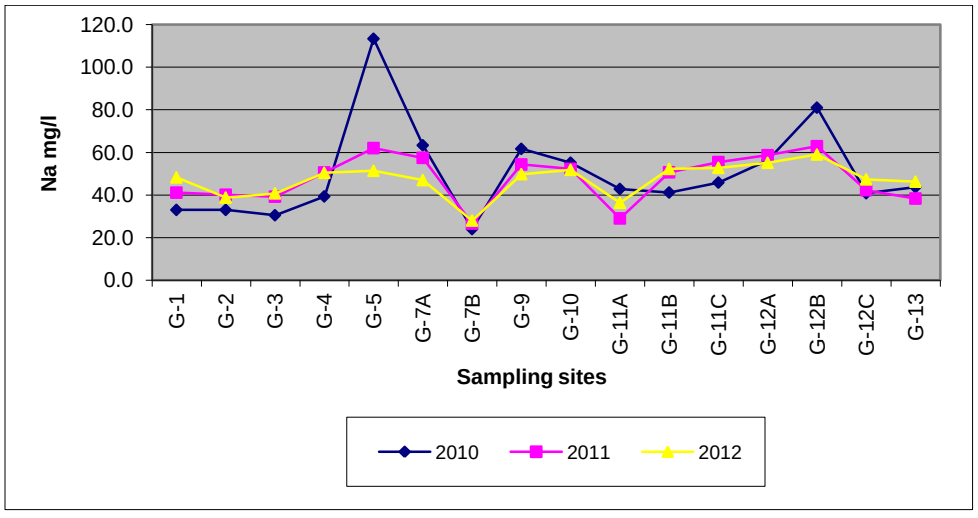


Fig 67: Graphical presentation of Chloride in ground water

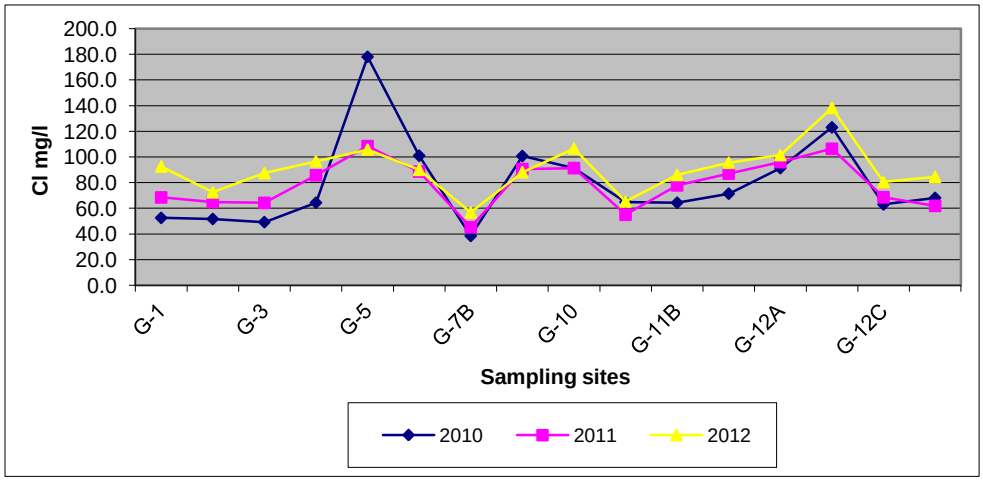


Fig 68: Graphical presentation of Potassium in ground water

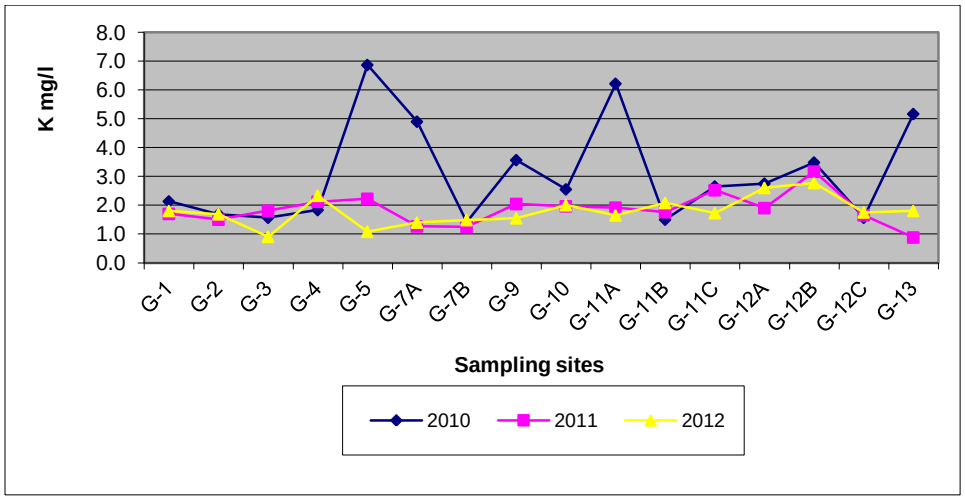


Fig 69: Graphical presentation of Sulphate in ground water

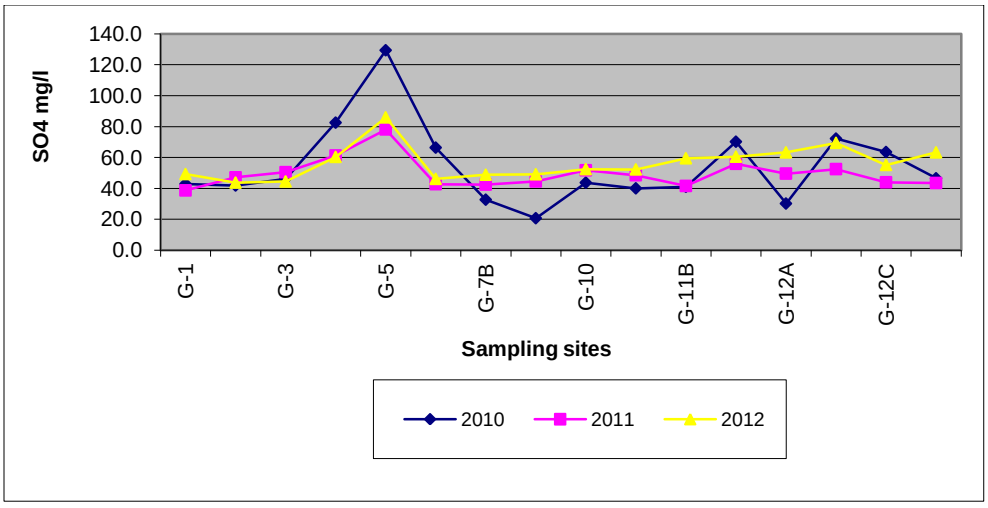


Fig 70: Graphical presentation of Carbonate in ground water

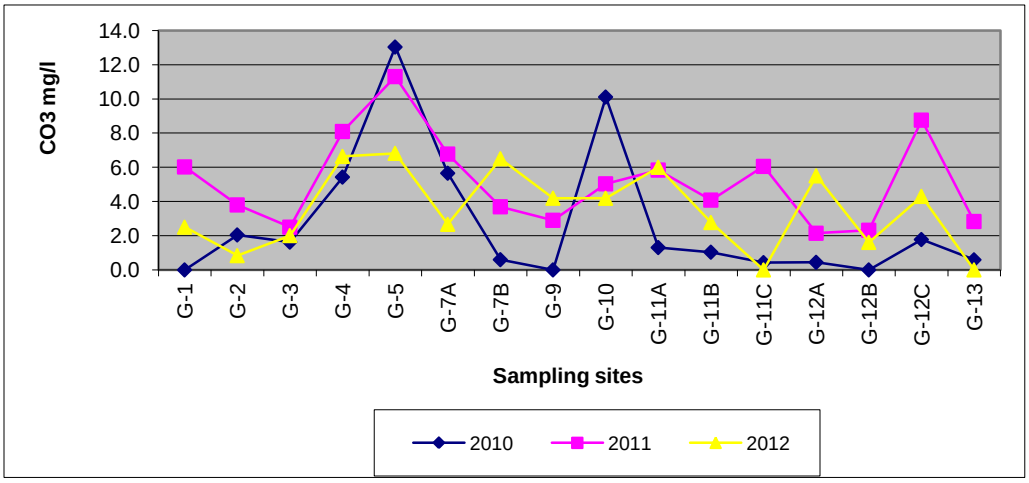


Fig 71: Graphical presentation of Bi-Carbonate in ground water

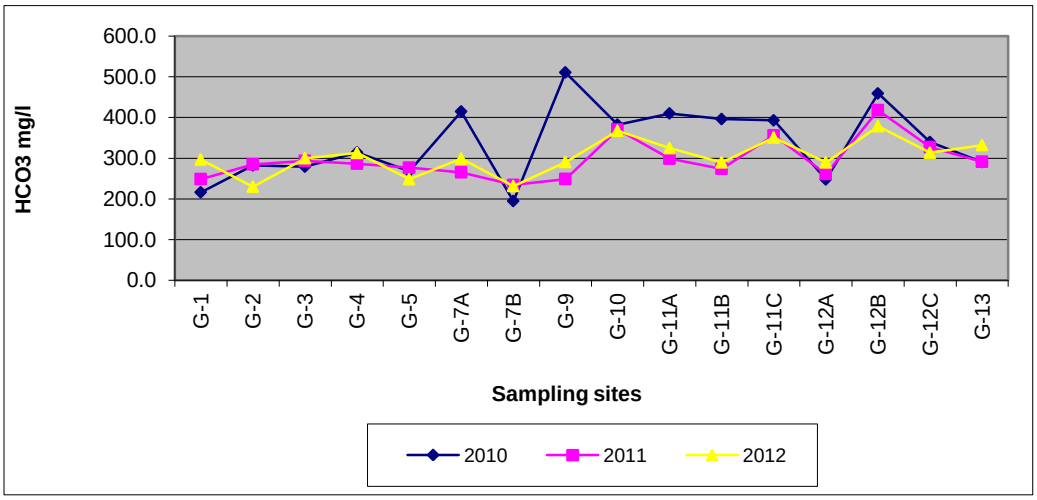


Table 10: Ground water quality of Shahpura lake basin (year 2010)

2010		General			Pollution indicator parameters					Hardness	Major Ions							
		pH_GEN	EC_GEN	TDS	NO2+NO3	p-TOT	Fe	F	COD	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
Sites		pH units	µmho/cm	mg/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Avg	7.5	593.2	377.8	27.1	0.1		0.2	36.2	240.7	64.8	19.1	33.0	2.1	52.5	42.8	0.0	216.1
	Min	7.4	437.0	280.0	17.7	0.0		0.0	26.0	184.0	48.0	13.6	29.0	1.0	42.0	34.0	0.0	171.6
G-01	Max	7.5	760.0	486.0	42.5	0.2		0.3	44.0	312.0	84.8	24.3	39.0	5.0	65.7	56.0	0.0	271.2
	Avg	7.9	613.7	407.2	8.3	0.1		0.1	1.0	287.0	74.7	24.4	33.0	1.7	51.7	41.8	2.0	282.3
	Min	7.6	500.0	340.0	5.8	0.0		0.0	1.0	248.0	67.2	19.4	28.0	0.4	44.0	32.0	0.0	231.1
G-02	Max	8.0	696.0	438.0	13.7	0.1		0.2	1.0	308.0	80.0	26.2	42.0	4.3	63.0	48.0	3.0	318.0
	Avg	7.8	644.0	411.8	14.6	0.1		0.1	6.9	296.0	81.9	22.2	30.5	1.6	49.2	46.2	1.6	279.0
	Min	7.6	470.0	313.0	8.9	0.0		0.0	1.0	236.0	59.2	12.6	24.0	0.5	38.0	22.0	1.2	226.6
G-03	Max	7.9	780.0	530.0	25.2	0.1		0.2	16.0	384.0	107.2	31.1	38.0	4.2	69.0	62.0	2.6	345.6
	Avg	8.1	786.8	494.0	14.6	0.1		0.2	13.1	371.3	74.9	44.7	39.3	1.8	64.4	82.5	5.4	314.2
	Min	7.8	664.0	445.0	9.7	0.0		0.0	6.2	324.0	65.6	36.0	34.0	0.6	50.0	62.0	1.7	269.9
G-04	Max	8.5	975.0	542.0	22.1	0.1		0.5	20.0	432.0	92.0	62.2	45.0	4.1	76.0	102.0	10.4	349.5
	Avg	8.4	1110.3	730.7	12.0	0.0		0.2	1.0	372.0	109.6	23.8	113.3	6.9	178.1	129.3	13.0	267.8
	Min	8.3	1081.0	692.0	8.4	0.0		0.0	1.0	352.0	104.8	21.4	102.0	5.2	153.0	110.0	9.6	256.2
G-05	Max	8.5	1150.0	766.0	14.2	0.0		0.3	1.0	388.0	115.2	28.2	123.0	9.5	194.0	140.0	15.1	274.0
	Avg	8.3	851.3	558.3	0.4	0.1		0.1	1.0	354.7	88.0	32.7	63.3	4.9	101.0	66.3	5.7	414.7
	Min	8.2	814.0	527.0	0.4	0.1		0.0	1.0	304.0	80.0	22.4	62.0	4.2	99.0	56.0	0.0	370.9
G-07A	Max	8.3	890.0	584.0	0.4	0.1		0.2	1.0	388.0	99.2	45.7	65.0	6.2	103.0	72.0	9.6	480.7
	Avg	7.8	510.5	313.3	8.6	0.1		0.1	1.0	197.3	50.1	17.5	24.0	1.4	38.5	32.7	0.6	194.5
	Min	7.6	410.0	262.0	5.3	0.0		0.0	1.0	160.0	41.6	13.6	20.0	0.5	32.0	28.0	0.0	163.0
G-07B	Max	8.0	630.0	404.0	10.2	0.1		0.2	1.0	260.0	64.8	23.8	29.0	2.7	47.0	42.0	2.3	239.7
	Avg	7.3	975.7	624.3	15.8	0.2		0.7	44.3	466.0	107.5	48.0	61.7	3.6	100.7	20.7	0.0	510.8
	Min	7.2	880.0	563.0	12.0	0.2		0.5	40.0	428.0	100.0	43.3	54.0	2.1	90.1	18.0	0.0	488.0
G-09	Max	7.4	1050.0	672.0	17.7	0.3		1.0	52.8	500.0	112.0	54.4	66.0	4.5	110.0	24.0	0.0	531.9
	Avg	8.2	866.0	568.5	18.4	0.2		0.7	31.3	405.0	103.7	35.4	55.2	2.6	91.4	43.7	10.1	382.5
	Min	8.0	696.0	485.0	13.7	0.1		0.2	22.0	378.0	90.4	27.7	30.0	0.4	48.0	34.0	3.5	368.5
G-10	Max	8.5	990.0	634.0	22.6	0.3		1.0	45.7	468.0	112.0	45.7	74.0	6.2	133.3	49.0	25.2	405.0

2010		General			Pollution indicator parameters					Hardness	Major Ions							
		pH_GEN	EC_GEN	TDS	NO2+NO3	p-TOT	Fe	F	COD	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
Sites		pH units	µmho/cm	mg/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
G-11A	Avg	8.0	756.8	504.2	18.0	0.5		0.4	47.9	376.7	95.7	33.4	42.8	6.2	65.0	40.0	1.3	410.0
	Min	7.9	610.0	390.0	14.6	0.2		0.0	32.0	292.0	80.0	22.4	25.0	1.5	34.7	13.0	0.0	300.5
	Max	8.2	913.0	593.0	21.7	1.0		1.0	64.0	468.0	123.2	39.9	60.0	14.4	94.0	72.0	3.1	536.8
G-11B	Avg	7.9	793.8	495.0	13.9	0.1		0.1	1.0	366.7	99.2	28.8	41.2	1.5	64.3	41.0	1.0	396.0
	Min	7.6	664.0	431.0	12.4	0.0		0.0	1.0	300.0	78.4	16.5	38.0	0.4	54.0	29.0	0.0	326.8
	Max	8.1	860.0	550.0	16.8	0.1		0.2	1.0	420.0	116.8	38.9	45.0	2.8	75.0	52.0	2.9	449.0
G-11C	Avg	7.9	810.7	542.2	22.9	0.1		0.6	9.4	380.7	110.5	25.3	45.8	2.7	71.4	70.2	0.4	392.9
	Min	7.5	720.0	510.0	12.2	0.1		0.0	2.0	292.0	88.0	17.5	32.0	0.4	46.0	51.0	0.0	311.1
	Max	8.2	908.0	590.0	35.0	0.2		1.0	20.0	432.0	119.2	34.0	62.0	5.8	100.7	82.0	2.6	434.3
G-12A	Avg	7.6	651.3	420.3	4.8	0.1		0.2	7.9	206.3	46.7	21.8	56.3	2.8	91.3	30.2	0.4	247.6
	Min	7.5	630.0	403.0	4.4	0.0		0.0	6.0	188.0	43.2	19.4	52.0	1.8	84.0	14.0	0.0	235.1
	Max	7.8	680.0	456.0	5.3	0.1		0.4	9.1	242.0	52.0	27.2	60.0	4.6	100.0	58.0	1.5	267.0
G-12B	Avg	7.9	1079.2	695.5	29.7	0.1		0.1	1.0	471.8	134.0	33.2	81.0	3.5	123.1	72.2	0.0	459.1
	Min	7.7	860.0	550.0	22.1	0.0		0.0	1.0	404.0	93.6	19.4	34.0	0.4	54.0	55.0	0.0	429.4
	Max	8.1	1350.0	864.0	40.7	0.1		0.3	1.0	552.0	165.6	45.2	132.0	6.8	201.4	86.0	0.0	488.0
G-12C	Avg	7.7	737.7	492.5	19.2	0.1		0.5	1.0	374.0	93.2	34.3	40.8	1.6	63.0	63.5	1.8	339.5
	Min	7.6	650.0	436.0	5.8	0.0		0.1	1.0	324.0	64.8	26.2	38.0	0.2	60.0	55.0	1.2	310.8
	Max	7.8	872.0	540.0	31.9	0.1		1.0	1.0	408.0	116.8	41.8	47.0	3.2	69.0	73.0	2.1	349.9
G-13	Avg	7.7	685.3	441.1	22.9	0.1		0.3	1.0	282.7	65.7	28.8	43.7	5.2	68.1	46.5	0.6	290.3
	Min	7.5	560.0	358.0	3.5	0.0		0.0	1.0	244.0	49.6	24.3	40.0	1.6	58.0	24.0	0.0	235.3
	Max	7.9	880.0	560.0	46.9	0.1		0.5	1.0	320.0	84.8	33.1	50.0	18.0	81.0	74.0	1.4	331.8

Table 11: Ground water quality of Shahpura lake basin (year 2011)

2011		General			Pollution indicator parameters					Hardness	Major Ions							
		pH_GEN	EC_GEN	TDS	NO2+NO3	p-TOT	Fe	F	COD	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
Sites		pH units	µmho/cm	mg/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Avg	8.0	682.6	436.8	26.0	0.1	0.2	0.4	30.3	289.3	74.2	25.3	41.1	1.7	68.5	38.7	6.0	248.5
	Min	7.5	480.0	307.0	13.3	0.1	0.0	0.0	22.0	190.0	51.2	15.1	33.0	0.4	52.0	28.0	0.0	178.9
G-01	**Max**	8.4	840.0	538.0	41.2	0.2	0.4	1.0	33.0	390.0	105.6	34.0	55.0	4.0	89.1	48.0	20.2	318.4
	Avg	8.1	691.4	425.9	11.4	0.1	0.3	0.2	1.1	294.4	76.4	25.1	40.1	1.5	64.9	47.1	3.8	284.9
	Min	7.5	520.0	333.0	4.4	0.0	0.2	0.0	1.0	268.0	72.0	21.3	32.0	0.2	42.0	36.0	0.0	260.0
G-02	**Max**	8.4	804.0	461.0	18.6	0.2	0.4	0.3	1.3	312.0	80.8	26.7	48.0	3.4	78.0	58.0	8.0	300.0
	Avg	8.0	733.9	456.9	16.1	0.2	0.3	0.5	10.7	295.8	76.9	26.6	39.2	1.8	64.2	50.4	2.5	293.4
	Min	7.8	616.0	360.0	8.0	0.1	0.2	0.2	1.0	240.0	62.4	20.3	30.0	0.1	42.0	30.0	0.0	240.2
G-03	**Max**	8.5	820.0	524.0	26.6	0.2	0.4	0.9	22.7	362.0	98.0	39.4	52.0	5.1	80.0	66.0	10.1	346.5
	Avg	8.3	754.6	478.9	10.2	0.1	0.1	0.6	20.7	352.1	74.7	41.3	50.6	2.1	85.7	61.3	8.1	286.6
	Min	8.0	669.3	442.0	4.4	0.1	0.0	0.2	9.0	302.0	68.8	31.6	38.0	0.2	66.0	29.0	0.0	240.0
G-04	**Max**	8.5	870.0	512.0	15.5	0.2	0.2	0.9	26.0	400.0	83.6	49.6	56.1	3.7	100.0	96.0	14.4	319.9
	Avg	8.3	1037.8	635.8	11.3	0.1	0.3	0.4	2.7	337.6	94.7	24.7	66.8	2.7	118.6	84.1	11.4	278.6
	Min	7.9	710.0	426.0	5.8	0.0	0.2	0.1	1.0	204.0	48.0	17.5	41.1	0.4	74.6	44.0	0.0	171.4
G-05	**Max**	8.6	1250.0	768.0	17.7	0.2	0.3	1.0	5.3	400.0	113.6	33.5	105.0	6.7	200.0	132.0	24.0	339.7
	Avg	8.3	766.1	474.2	15.3	0.2	0.2	0.3	19.5	292.3	71.8	26.0	57.4	1.3	88.6	42.7	6.8	265.3
	Min	7.6	619.0	396.0	7.8	0.1	0.1	0.2	2.0	256.0	64.0	19.3	42.0	0.3	71.0	17.0	0.0	233.8
G-07A	**Max**	8.5	845.0	544.0	26.6	0.2	0.2	0.5	35.0	312.0	83.2	35.0	80.0	2.8	105.0	50.0	12.0	312.0
	Avg	8.0	577.4	363.0	9.1	0.1	0.1	0.2	9.6	256.6	62.7	23.0	26.6	1.2	45.2	42.4	3.7	234.1
	Min	7.4	420.0	269.0	6.6	0.0	0.1	0.2	1.0	210.0	48.0	14.1	20.0	0.1	32.0	30.0	0.0	177.3
G-07B	**Max**	8.5	680.0	435.0	11.1	0.2	0.2	0.3	17.5	304.0	74.4	31.1	35.0	2.9	62.0	55.0	10.0	268.0
	Avg	8.1	747.4	455.1	10.7	0.1	0.1	0.4	11.2	268.9	70.5	22.7	54.3	2.0	90.6	44.5	2.9	248.8
	Min	7.4	654.0	383.3	4.4	0.0	0.1	0.0	1.0	220.0	64.1	12.2	48.0	1.1	80.0	27.0	0.0	189.1
G-09	**Max**	8.7	880.0	564.0	17.3	0.3	0.2	1.0	24.0	328.0	76.1	37.9	65.0	4.1	105.1	58.6	5.2	281.7
	Avg	8.1	942.4	583.7	18.9	0.1	0.1	0.5	24.9	372.2	97.0	31.5	52.2	2.0	91.3	51.7	5.0	370.3
	Min	7.8	870.0	498.0	14.2	0.1	0.0	0.2	18.0	340.0	88.0	26.7	35.0	0.5	52.0	34.0	0.0	354.0
G-10	**Max**	8.4	1003.1	642.0	23.0	0.3	0.1	1.0	34.0	424.0	107.0	37.9	75.0	3.9	118.0	62.3	12.0	385.5

2011		General			Pollution indicator parameters					Hardness	Major Ions							
		pH_GEN	EC_GEN	TDS	NO2+NO3	p-TOT	Fe	F	COD	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
Sites		pH units	µmho/cm	mg/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Avg	8.2	646.0	413.5	22.0	0.6	0.1	0.3	34.0	329.0	89.4	27.0	29.0	1.9	55.0	48.5	5.8	298.8
	Min	8.1	620.0	397.0	17.7	0.3	0.0	0.2	27.3	320.0	76.9	16.5	22.0	1.3	36.9	39.0	0.0	275.8
G-11A	**Max**	8.4	660.0	422.0	26.6	1.0	0.3	0.4	40.0	344.0	104.2	35.0	38.0	2.5	75.0	71.0	12.0	320.0
	Avg	8.2	723.2	439.3	8.6	0.2	0.1	0.4	14.7	295.0	75.2	26.0	50.7	1.8	77.9	41.6	4.1	274.0
	Min	7.8	586.0	328.0	2.7	0.1	0.1	0.3	4.0	186.0	40.0	14.8	42.0	0.4	68.0	20.0	0.0	164.8
G-11B	**Max**	8.4	890.0	570.0	26.6	0.3	0.3	0.6	38.4	404.0	113.0	31.8	62.0	4.1	85.3	54.0	10.0	392.0
	Avg	8.1	827.2	528.0	22.1	0.1	0.0	0.3	4.0	362.9	98.5	28.7	55.4	2.5	87.0	55.9	6.1	356.0
	Min	7.8	725.0	465.0	6.6	0.0	0.0	0.0	2.6	320.0	75.2	16.0	39.0	0.4	70.0	28.0	0.0	311.3
G-11C	**Max**	8.4	872.0	557.0	32.8	0.1	0.0	0.5	5.8	424.0	116.8	41.7	74.0	4.7	104.0	86.0	19.2	409.9
	Avg	7.9	744.1	470.1	8.4	0.1	0.1	0.3	10.0	260.4	60.7	26.6	58.7	1.9	96.0	49.6	2.1	261.1
	Min	7.6	680.0	435.0	5.3	0.0	0.1	0.0	7.0	212.0	51.2	20.4	44.0	0.4	84.0	10.0	0.0	220.7
G-12A	**Max**	8.2	858.0	493.9	13.3	0.2	0.2	0.7	12.0	316.0	77.6	30.1	70.0	4.1	109.0	82.0	4.1	297.2
	Avg	8.1	1043.3	666.6	28.3	0.1	0.1	0.3	5.9	431.9	108.4	39.3	62.9	3.2	106.4	52.4	2.1	421.0
	Min	7.8	900.0	582.0	19.9	0.1	0.1	0.2	4.8	309.0	62.4	20.9	42.0	0.4	65.0	36.0	0.0	322.8
G-12B	**Max**	8.3	1400.0	896.0	44.3	0.3	0.1	0.4	8.0	600.0	141.0	60.3	90.0	6.8	142.0	72.0	5.8	478.2
	Avg	8.1	832.0	522.6	27.4	0.1	0.1	0.4	1.0	381.8	94.6	36.0	42.3	1.7	68.6	43.9	8.8	327.3
	Min	7.8	725.0	465.0	13.3	0.1	0.1	0.3	1.0	320.0	67.2	30.1	30.0	0.1	56.7	30.0	0.0	311.3
G-12C	**Max**	8.4	890.0	544.0	36.3	0.2	0.1	0.6	1.0	432.0	121.6	42.8	52.0	4.0	82.0	64.0	20.2	360.4
	Avg	8.1	726.0	454.5	28.3	0.1	0.1	0.5	3.5	318.0	71.3	34.0	38.3	0.9	61.9	43.4	2.8	291.2
	Min	7.6	651.0	366.6	16.8	0.0	0.1	0.2	1.0	282.0	60.8	29.1	18.0	0.1	34.0	24.0	0.0	234.3
G-13	**Max**	8.4	860.0	550.0	37.2	0.2	0.1	1.0	6.0	364.0	80.2	41.8	54.0	1.4	88.0	72.0	5.5	316.0

Table 12: Ground water quality of Shahpura lake basin (year 2012)

2012		General			Pollution indicator parameters					Hardness	Major Ions							
		pH_GEN	EC_GEN	TDS	NO2+NO3	p-TOT	Fe	F	COD	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
Sites		pH units	µmho/cm	mg/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Avg	8.1	857.5	548.5	30.1	0.2	0.4	0.4	21.4	363.5	98.1	29.1	48.3	1.8	92.5	49.3	2.5	296.5
	Min	7.8	600.0	384.0	11.1	0.0	0.3	0.3	8.4	264.0	72.0	20.4	36.0	1.3	74.0	36.0	0.0	212.0
G-01	Max	8.5	1410.0	902.0	51.8	0.3	0.6	0.5	34.0	540.0	160.0	35.4	65.0	2.9	120.0	77.0	10.0	344.0
	Avg	8.0	657.4	413.0	10.9	0.2	0.4	0.2	1.0	241.6	63.1	18.8	38.8	1.7	72.5	43.7	0.8	229.9
	Min	7.6	293.0	187.0	8.3	0.1	0.2	0.2	1.0	104.0	32.0	5.8	12.0	0.5	32.0	20.0	0.0	84.0
G-02	Max	8.2	900.0	576.0	12.8	0.2	0.8	0.3	1.1	292.3	76.1	24.9	52.0	3.2	112.0	54.0	3.3	280.0
	Avg	8.0	740.5	464.3	13.6	0.2	0.4	0.4	12.1	320.9	82.9	30.6	40.8	1.5	78.6	45.6	3.0	297.7
	Min	7.6	616.0	360.0	2.3	0.1	0.2	0.2	1.0	240.0	62.4	20.3	30.0	0.1	42.0	30.0	0.0	240.2
G-03	Max	8.5	820.0	524.0	26.6	0.2	0.7	0.9	22.7	364.0	99.3	39.4	52.0	5.1	130.0	66.0	10.1	346.5
	Avg	8.2	845.9	542.6	14.7	0.1	0.4	0.4	20.1	367.9	88.3	36.7	50.4	2.3	96.6	60.3	6.6	312.8
	Min	8.0	748.5	484.3	7.5	0.1	0.1	0.3	17.6	319.5	80.0	32.6	44.0	1.9	88.0	50.0	0.0	267.2
G-04	Max	8.4	1050.0	672.0	17.7	0.2	0.9	0.4	22.0	460.0	112.0	43.7	58.0	2.9	105.0	67.0	12.0	340.0
	Avg	7.9	1130.2	668.3	9.7	0.2	0.6	0.4	4.1	387.5	101.2	25.5	51.4	1.1	105.8	85.9	6.8	248.1
	Min	7.4	970.6	402.1	8.7	0.2	0.3	0.3	0.0	340.0	92.1	22.5	30.7	0.1	60.8	55.4	0.0	220.0
G-05	Max	8.1	1210.0	774.0	11.7	0.2	0.8	0.6	8.8	412.0	112.0	29.2	84.0	2.5	188.0	144.0	10.3	259.8
	Avg	7.9	852.7	535.7	8.9	0.3	0.3	0.3	20.8	301.4	73.4	26.1	47.0	1.4	90.0	46.1	2.7	299.0
	Min	7.4	773.9	456.6	3.6	0.2	0.2	0.3	5.0	260.0	61.3	20.4	40.0	0.9	72.0	42.0	0.0	260.0
G-07A	Max	8.1	1020.0	652.0	14.2	0.4	0.6	0.4	36.4	380.0	84.9	40.8	54.0	1.9	126.0	51.0	8.0	340.0
	Avg	8.1	638.3	408.2	11.2	0.2	0.4	0.3	15.9	244.5	59.0	20.4	28.0	1.5	56.8	48.8	6.5	231.5
	Min	7.6	600.0	384.0	7.5	0.1	0.2	0.3	11.5	240.0	53.3	16.5	20.0	0.3	36.0	42.3	0.0	208.0
G-07B	Max	8.4	720.0	460.0	17.7	0.2	0.7	0.3	20.0	254.0	68.9	24.3	32.0	2.4	78.0	59.0	16.0	254.0
	Avg	7.7	862.8	561.3	21.8	0.1	0.4	0.3	18.6	368.1	91.1	33.9	49.8	1.5	88.1	49.1	4.2	290.5
	Min	7.0	681.5	404.3	2.2	0.1	0.3	0.3	6.2	228.5	67.4	14.6	40.0	1.2	66.0	19.5	0.0	242.0
G-09	Max	8.3	1100.0	704.0	66.4	0.2	0.6	0.4	29.1	500.0	117.0	52.5	62.0	1.9	98.0	64.0	10.0	360.0
	Avg	8.0	1076.7	664.2	18.3	0.2	0.3	0.4	16.9	443.0	111.3	40.1	51.8	2.0	106.6	52.4	4.2	367.3
	Min	7.3	924.0	587.9	1.9	0.2	0.0	0.3	0.0	360.0	94.2	29.7	44.0	0.8	88.0	19.5	0.0	312.0
G-10	Max	8.3	1380.0	883.0	25.1	0.2	0.8	0.4	26.0	620.0	145.0	62.3	60.0	2.9	144.0	84.0	8.8	411.0

2012		General			Pollution indicator parameters					Hardness	Major Ions							
		pH_GEN	EC_GEN	TDS	NO2+NO3	p-TOT	Fe	F	COD	Har_Total	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
		pH units	µmho/cm	mg/L	mg N/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Avg	8.1	739.0	472.7	19.3	0.5	0.9	0.4	31.5	359.2	87.7	28.1	36.3	1.6	65.3	52.3	6.0	324.7
	Min	7.7	680.0	435.0	6.2	0.4	0.9	0.4	28.0	341.6	82.4	24.0	33.0	1.2	56.0	41.8	0.0	320.0
G-11A	Max	8.3	837.0	535.0	26.6	0.6	0.9	0.4	35.2	372.0	93.1	32.1	40.0	2.0	72.0	65.0	10.0	334.0
	Avg	8.0	862.5	549.2	44.4	0.2	0.4	0.4	17.3	369.5	105.0	28.8	52.2	2.1	86.0	59.4	2.8	289.6
	Min	7.6	680.0	435.0	11.2	0.1	0.2	0.3	8.5	284.0	86.4	25.7	47.0	0.9	84.0	47.2	0.0	280.0
G-11B	Max	8.3	1080.0	691.0	109.2	0.2	0.6	0.6	28.0	480.0	136.7	34.0	56.9	3.2	90.0	89.0	5.6	304.0
	Avg	8.1	882.6	562.3	25.6	0.1	0.2	0.4	7.3	362.0	93.1	32.2	52.8	1.7	95.5	60.5	0.0	350.5
	Min	7.7	822.3	517.1	16.8	0.1	0.0	0.4	2.8	348.0	84.1	21.4	38.0	1.2	74.0	38.0	0.0	304.0
G-11C	Max	8.4	940.0	601.0	36.9	0.2	0.6	0.5	17.6	372.0	104.1	37.4	65.0	2.1	120.0	70.0	0.0	392.0
	Avg	8.1	882.0	564.5	23.9	0.1	0.4	0.5	14.3	328.5	81.4	31.0	55.1	2.6	101.5	63.3	5.5	289.5
	Min	7.8	740.0	473.6	10.2	0.1	0.2	0.3	12.6	244.0	54.8	25.8	52.0	1.8	94.0	58.0	0.0	264.0
G-12A	Max	8.3	1230.0	787.0	62.8	0.1	0.6	0.7	17.6	520.0	136.3	38.8	58.0	3.2	110.0	70.0	12.0	328.0
	Avg	7.6	1165.0	745.3	41.3	0.2	0.4	0.4	9.4	541.5	125.6	37.2	59.0	2.8	138.3	69.4	1.6	378.5
	Min	7.3	970.0	620.8	28.3	0.1	0.1	0.3	6.9	466.0	80.0	31.6	55.0	2.3	96.0	48.3	0.0	320.0
G-12B	Max	7.7	1520.0	972.0	68.2	0.3	0.6	0.4	14.5	700.0	152.3	48.6	68.0	3.4	246.0	104.0	4.0	424.0
	Avg	7.5	932.4	583.0	30.2	0.2	0.4	0.3	1.0	414.4	107.1	35.7	47.3	1.8	80.5	55.1	4.3	313.5
	Min	7.2	864.9	527.4	23.6	0.1	0.1	0.2	1.0	368.2	82.1	31.1	46.4	1.6	73.4	32.2	0.0	280.0
G-12C	Max	7.9	1000.0	640.0	38.5	0.3	0.6	0.4	1.0	472.0	134.0	39.5	48.0	1.9	90.0	84.0	8.8	340.0
	Avg	8.1	895.5	573.3	38.0	0.2	0.3	0.4	3.5	374.0	88.6	37.1	46.3	1.8	84.5	63.3	0.0	332.0
	Min	7.8	710.0	455.0	16.2	0.1	0.1	0.3	0.0	320.0	67.3	34.9	39.0	1.1	75.0	45.0	0.0	302.0
G-13	Max	8.5	1160.0	742.0	69.5	0.2	0.7	0.5	8.5	440.0	113.8	38.9	52.0	2.5	105.0	106.0	0.0	376.0

4.5 Sediment quality in Shahpura Lake

Sediment Temperatures- The temperature plays a crucial role in physical-chemical and biological behavior of aquatic system. The temperature of the sediment was recorded maximum 36.4^0C in Site-2, and minimum 24.457^0C in Site-1. In seasonal case maximum 27.295^oC sediment temperature recorded in summer and minimum 20.48^oC recorded in winter (Fig 19).

Moisture content- In present study of shahpura lake moisture content of sediment recorded maximum 81.956(%), in Site-10, and minimum 37.672(%) in Site-1. Moisture content maximum 55.997% recorded in monsoon season and minimum 33.467% recorded in winter season (Fig 20).

Specific gravity- In present study of shahpura lake specific gravity spatial recorded maximum value 1.669 in Site-7 and minimum value 1.119 in Site-10. In seasonal case maximum value 1.423 recorded in summer season and minimum 1.336 in winter season (Fig 21)

Conductivity- Conductivity is considered to be a rapid and good measure of dissolved solids. Conductivity is an important criterion in determining the suitability of water for irrigation. In present study maximum 303.928mho/cm conductivity founded in Site-10, , and minimum 123 mho/cm in Site-2. Whereas in summer season maximum conductivity 333.916 recorded and minimum 287.291mho/cm. in winter season (Fig 22).

TDS- TDS indicates the general nature of salinity of sediment. In shahpura lake sediment TDS maximum 396.928mg/g recorded in Site-11 and minimum 211.84mg/g. in Site-1 . In seasonal case maximum 269.62mg/g TDS recorded in monsoon season and minimum 185.893mg/g in winter season (Fig 23).

pH- pH are very most important parameters of water body and lake sediment. The present study sediment of Shahpura Lake the pH shows variation of different sites. Its maximum value 10.875 in Site-7. and minimum value 7.576 in Site-1 and in seasonal case maximum pH recorded during monsoon 7.78 and minimum during winter 7.66 (Fig 24)

Alkalinity- Alkalinity is due to the presence of bicarbonates, carbonates or hydroxides. The weathering of rocks is the potential source of alkalinity. In present study alkalinity of the sediment recorded maximum value 174.4mg/g in Site-9 and minimum value 112.8 mg/g in Site-12 In seasonal case maximum value 104.666mg/g recorded in winter season and minimum 98.5mg/g in summer season (Fig 25).

Calcium hardness- The main source of calcium in natural water are various types of rocks, industrial waters and sewage. In Shahpura lake chloride content in sediment recorded

maximum value 75.792mg/g in Site-11, and the minimum value 34.709mg/g in Site-1, In seasonal case maximum value 61.161mg/g recorded in monsoon season and minimum 30.163mg/g in winter season (Fig 26).

Magnesium hardness- The source of Mg hardness in natural water are various types of rocks, industrial wastes and sewage. In present study the Mg hardness of the sediment recorded maximum value 1.357mg/g in Site-12, and the minimum value 0.229mg/g in Site-1. Whereas in seasonal variation maximum value 0.554mg/g recorded in monsoon season and minimum value 0.444mg/g in summer season (Fig 27).

Chloride- High chloride content in sediment samples may be due to the pollution from chloride rich effluent of sewage and municipal waste. In Shahpura lake chloride content in sediment recorded maximum value 75.792mg/g in Site-11, and the minimum value 34.709mg/g in Site-1, In seasonal case maximum value 61.161mg/g recorded in monsoon season and minimum 30.163mg/g in winter season (Fig 28) .

Orthophosphate- Orthophosphate which are readily taken up by the phytoplankton (or lost to the sediment) often deplete rapidly becoming the first limiting nutrient. In present study the Orthophosphate of the sediment recorded maximum value 1.357mg/g in Site-12, and the minimum value 0.229mg/g in Site-1. Whereas in seasonal variation maximum value 0.554mg/g recorded in monsoon season and minimum value 0.444mg/g in summer season (Fig 29).

Organic matter- The organic matter is the very important to plants growth in sediment. In the present study organic matter in maximum value 9.057%, recorded in Site-9 and the minimum value 5.082(%). in Site-1, In seasonal case maximum value 5.816% recorded in monsoon season and minimum 5.149% in winter season (Fig 30).

Fig 72: Graphical presentation of soil temperature at Shahpura lake.

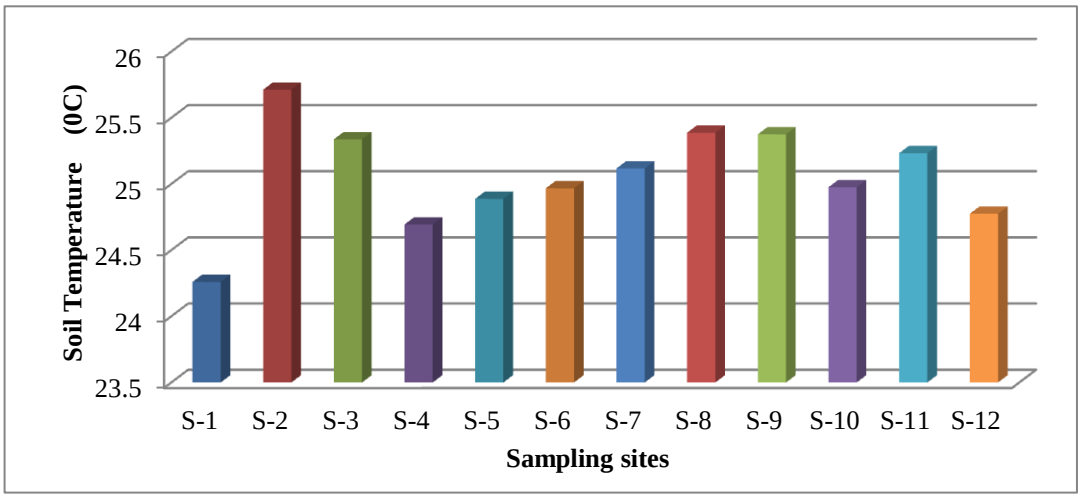


Fig 73: Graphical presentation of moisture content at Shahpura lake.

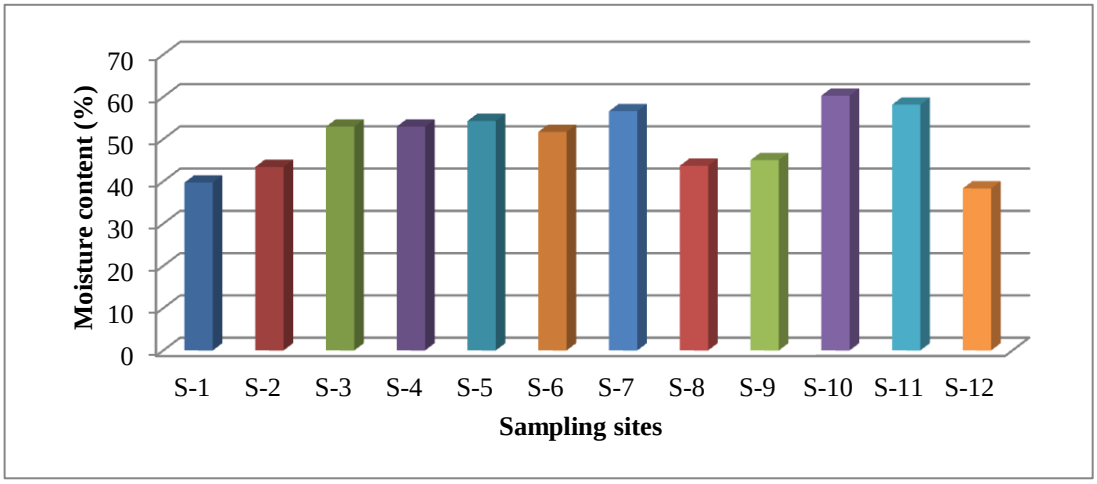


Fig 74: Graphical presentation of specific gravity at Shahpura lake.

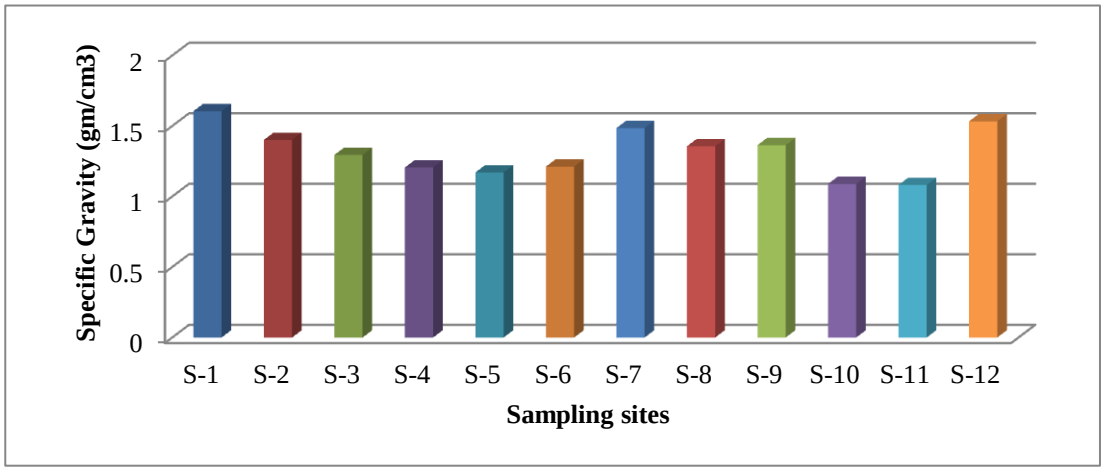


Fig 75: Graphical presentation of conductivity at Shahpura lake.

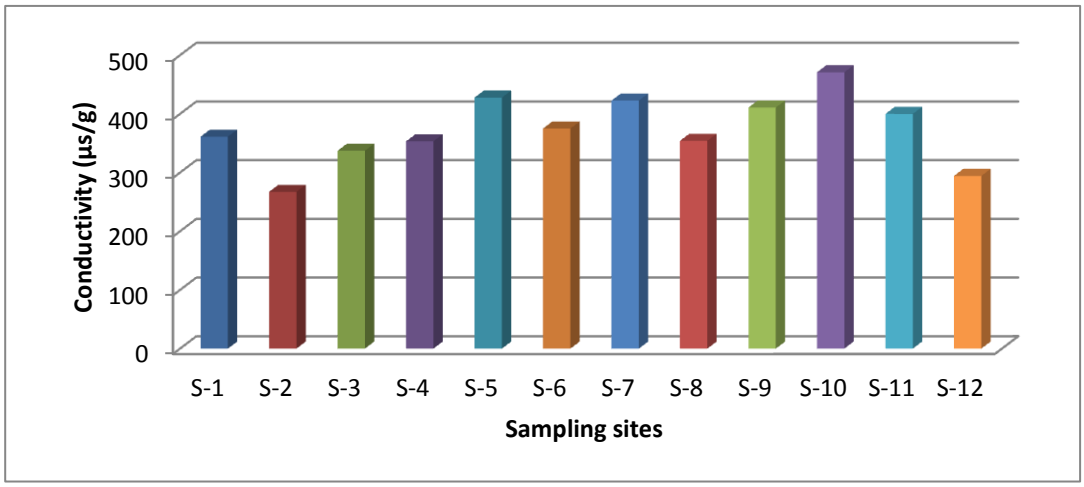


Fig 76: Graphical presentation of total dissolved solids at Shahpura lake.

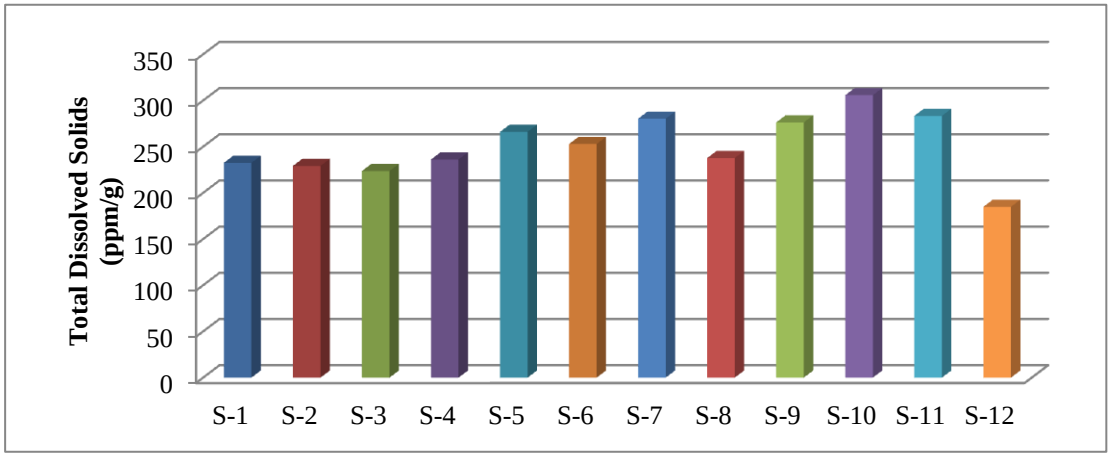


Fig 77: Graphical presentation of soil pH at Shahpura lake.

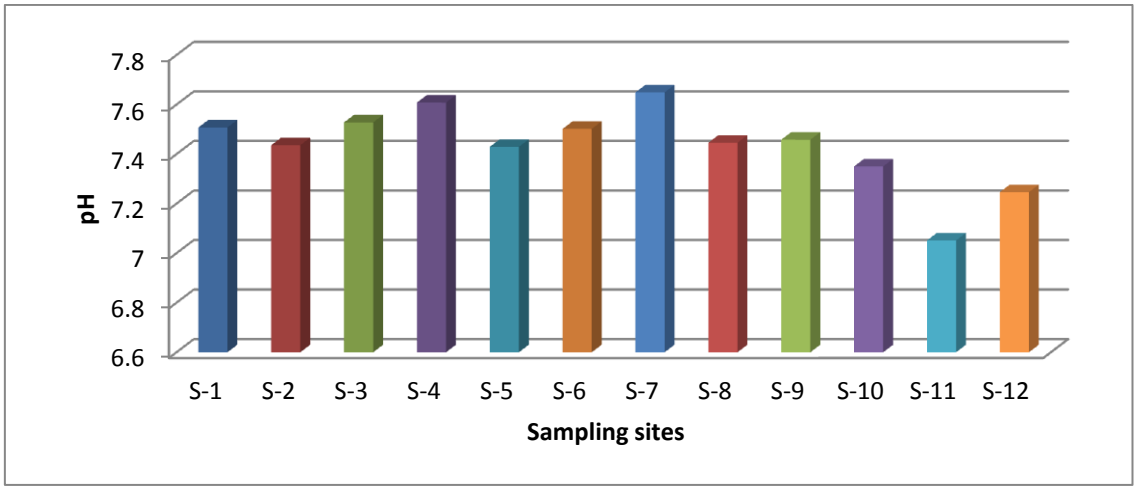


Fig 78: Graphical presentation of total alkalinity at Shahpura lake.

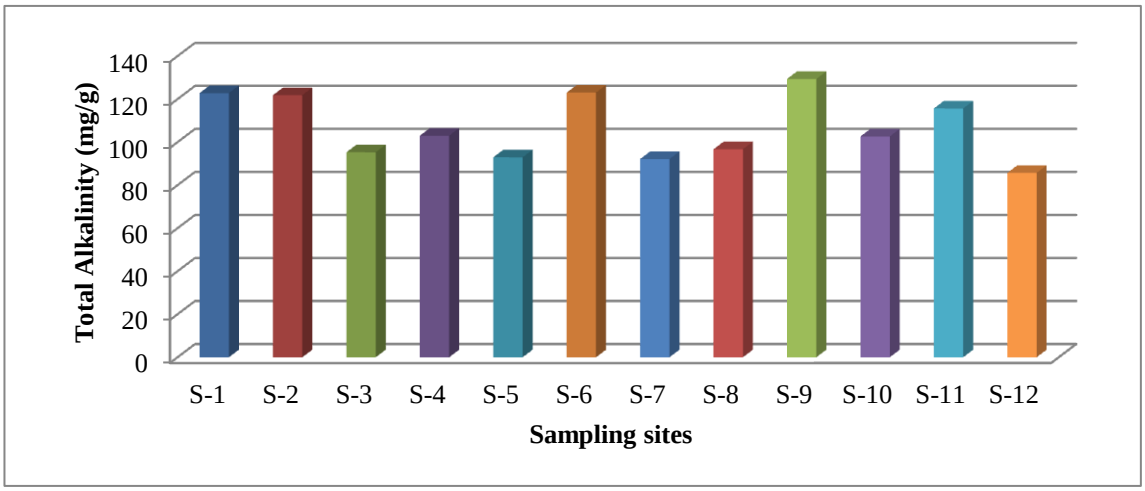


Fig 79: Graphical presentation of calcium hardness at Shahpura lake.

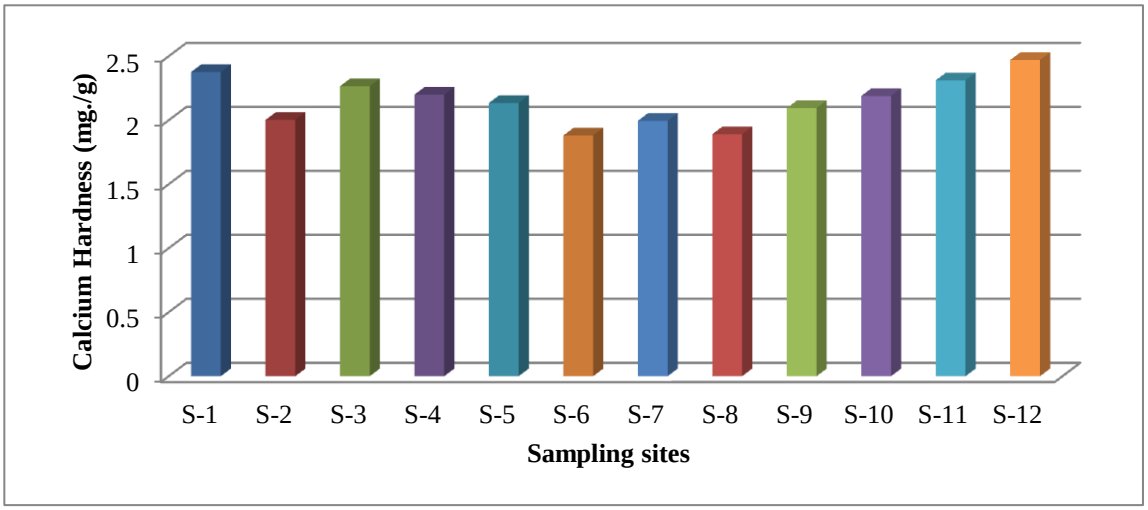


Fig 80: Graphical presentation of magnesium hardness at Shahpura lake.

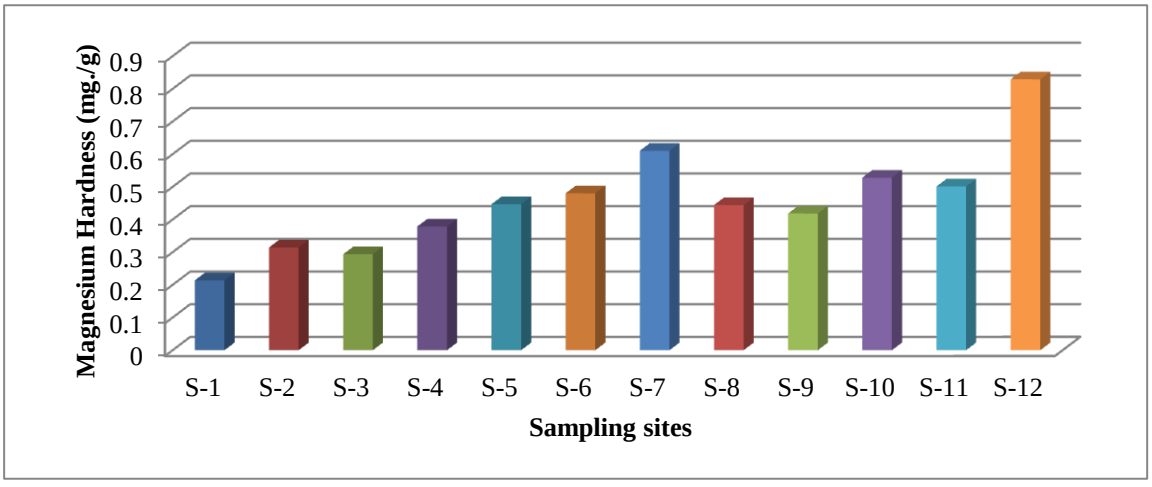


Fig 81: Graphical presentation of chloride at Shahpura lake.

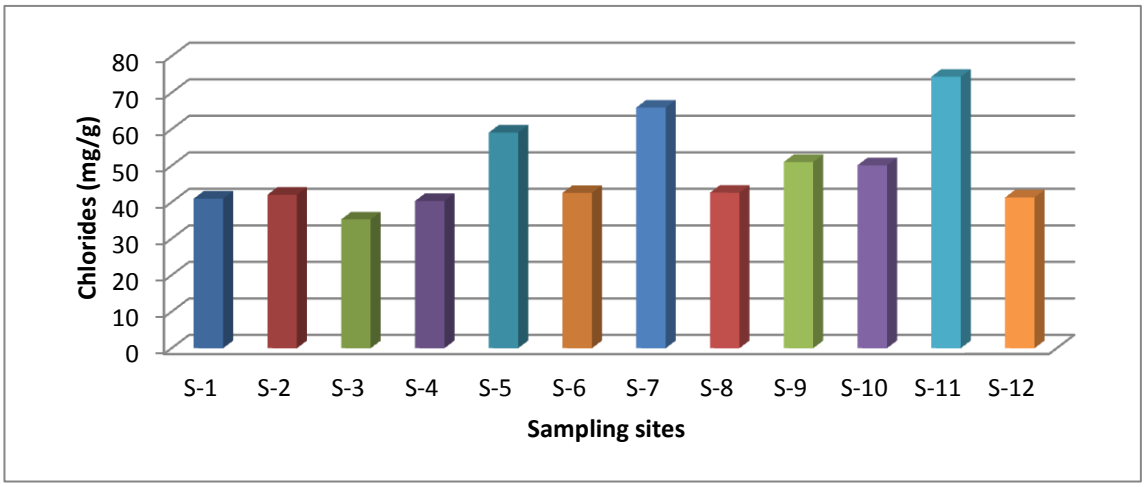


Fig 82: Graphical presentation of ortho-phosphate at Shahpura lake.

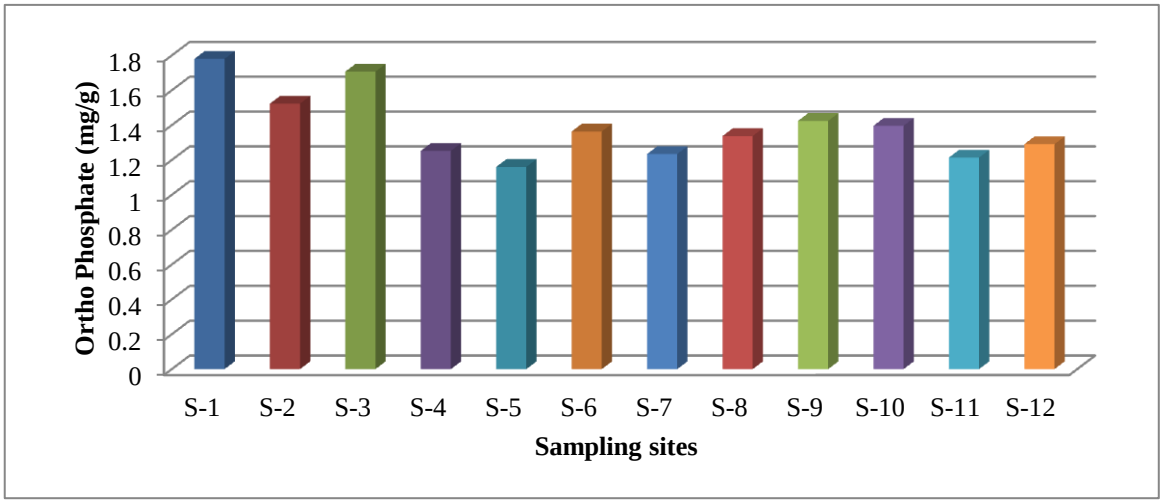


Fig 83: Graphical presentation of organic matter at Shahpura lake.

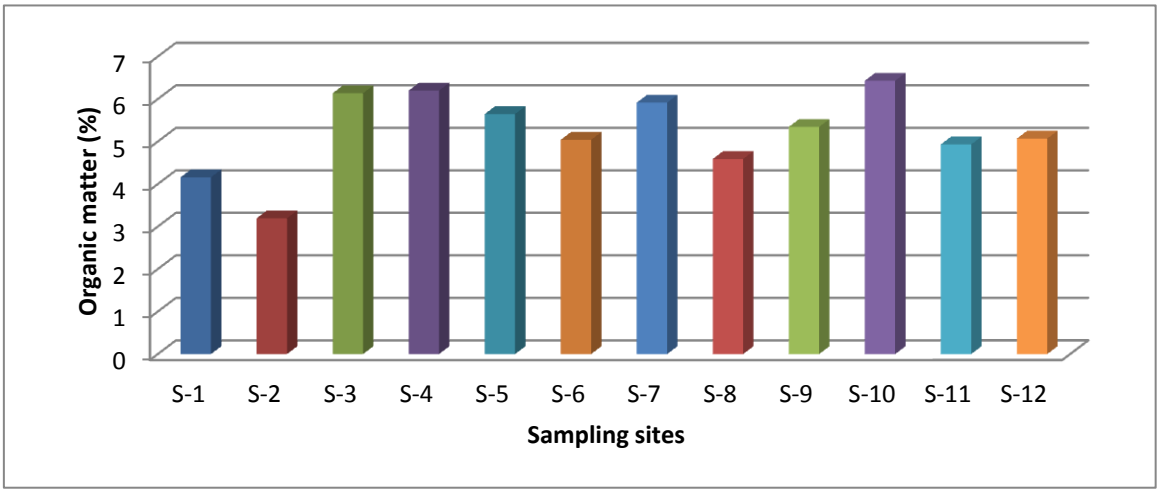


Table 13: Sediment quality of Shahpura lake

S No	Parameters	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**	**S-11**	**S-12**
1	Soil Temperature (^{0}C)	24.26	25.71	25.34	24.69	24.89	24.97	25.12	25.39	25.38	24.98	25.23	24.78
2	Moisture content (%)	39.72	43.42	52.96	52.97	54.30	51.72	56.61	43.69	45.04	60.29	58.16	38.34
3	Specific Gravity (gm/cm3)	1.61	1.40	1.30	1.21	1.17	1.21	1.49	1.36	1.36	1.09	1.08	1.53
4	Conductivity (µs/g)	361.18	267.10	337.17	353.17	427.74	375.03	422.71	354.11	410.84	470.87	399.97	294.26
5	Total Dissolved Solids (ppm/g)	232.50	229.17	223.69	236.13	266.03	252.94	280.33	237.70	276.29	305.79	283.35	184.90
6	pH	7.51	7.44	7.53	7.61	7.43	7.50	7.65	7.45	7.46	7.35	7.05	7.25
7	Total Alkalinity (mg/g)	122.80	121.85	95.30	103.00	92.95	123.05	92.15	96.70	129.38	102.65	115.65	85.70
8	Calcium Hardness (mg./g)	2.38	2.00	2.27	2.20	2.14	1.88	2.00	1.89	2.10	2.19	2.31	2.47
9	Magnesium Hardness (mg./g)	0.21	0.31	0.29	0.38	0.45	0.48	0.61	0.44	0.42	0.53	0.50	0.83
10	Chlorides (mg/g)	40.97	42.04	35.27	40.32	59.07	42.54	65.92	42.59	51.00	50.12	74.37	41.30
11	Ortho Phosphate (mg/g)	1.78	1.52	1.71	1.25	1.16	1.36	1.23	1.34	1.42	1.40	1.21	1.29
12	Organic matter (%)	4.16	3.19	6.14	6.20	5.65	5.04	5.92	4.59	5.34	6.43	4.93	5.07

B. Biological

A. Biological observation of Shahpura lake during Nov. 2011 to Oct. 2012.

a. Phytoplankton:

Total 150 phytoplankton species were reported belonging to 5 groups namely, Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae .Group Chlorophyceae had the highest number of species (53 species) followed by Euglenophyceae (34 species), Bacillariophyceae (32 species), Cyanophyceae (29 species), and 2 species of Dinophyceae. The maximum number of 101 species were recorded in the month of January where as minimum diversity of 13 species was recorded in the month of September. The maximum diversity of 33 species of phytoplankton was recorded at site 1 in the month of January and minimum diversity of 2 species of phytoplankton was recorded at site 2, site 7, site 9 and site 10 in the month of September. The phytoplankton density of Shahpura lake varied between 32 to 656 organisms/l. The maximum phytoplankton density 656 organisms/l was recorded at site 1 in the month of May and minimum density 32 organisms/l was recorded at site 10 in the month of September.

Group wise spatial and temporal variation of phytoplanktons:

Chlorophyceae:

A total 53 species of Chlorophyceae group were recorded during the study period. Chlorophyceae group showed maximum phytoplankton diversity in the month of January with 44 species and minimum in month of September with 8 species. In spatial case this group shows maximum diversity of 30 species at site 1 and minimum 17 species were recorded at site 6, site 7 and site 11 during the entire study period. Maximum density of Chlorophyceae group was found to be 170 organisms/l at site 8 in March and minimum density 2 organisms/l was recorded at site 1 and site 4 in the month of July.

Cyanophyceae:

A total 29 species of Cynophyceae group were recorded during the study period. Cyanophyceae group showed maximum phytoplankton diversity in month of May with 16 species at site 3 and minimum 8 species at Site 6 during the study period. The maximum density of Cyanophyceae group was found 406 organisms/l at Site 1 in the month of June and minimum was 24 organisms/l was recorded at Site-12 in the month of April.

Euglenophyceae:

A total 34 species of Euglenophyceae group were recorded during the study period. The diversity of Euglenophyceae group varied between 8 to 18 species. Maximum 18 species was

recorded at site 1 and minimum 8 species were recorded at site 5. The maximum density of Euglenophyceae group was found 362 organisms/l at site 1 in the month of January and minimum density 8 organisms/l at site 12 in the month of April.

Bacillariophyceae:

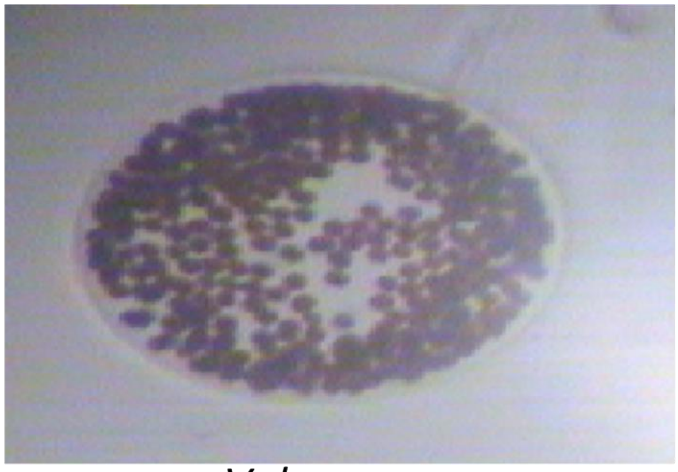
A total 32 species of Bacillariophyce group were recorded during the study period. Bacillariophyceae group shows maximum phytoplankton diversity 13 species at site 8 and minimum with 4 species at site 10. The maximum density of Bacillariophyceae group was found 64 organisms/l at site 12 in the month of September and minimum density 16 organisms/l was recorded at site 2, site 3 and site 6 in the month of March.

Dinophyceae:

Dinophyceae group were recorded in January, February and March with only 2 species. Density of Dinophyceae group showed 80 organisms/l at site 1, site and 10 in the month of January.

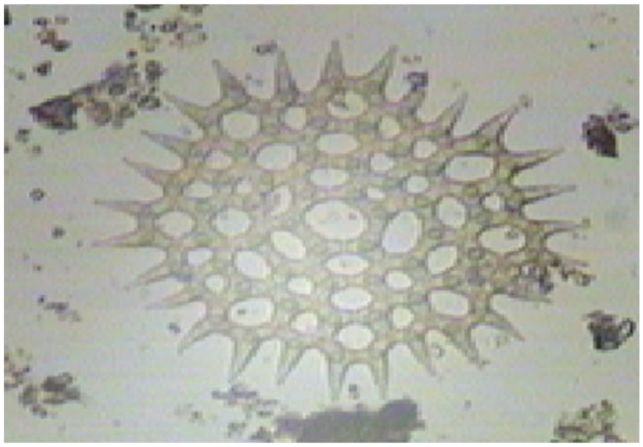
Plate –I: photographs of phytoplankton in Shahpura lake.

Pinnularia sp.

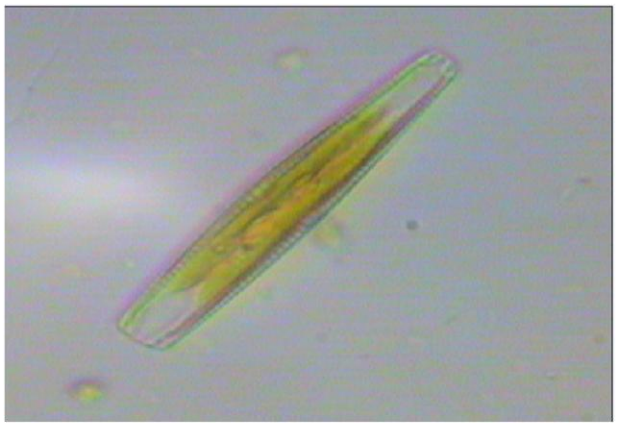


Volvox sp.

Frustullia sp.



Pediastrum duplex



Pleurosigma sp.

Ceratium sp.

Fig 84: Percentage composition of phytoplanktons in Shahapura lake

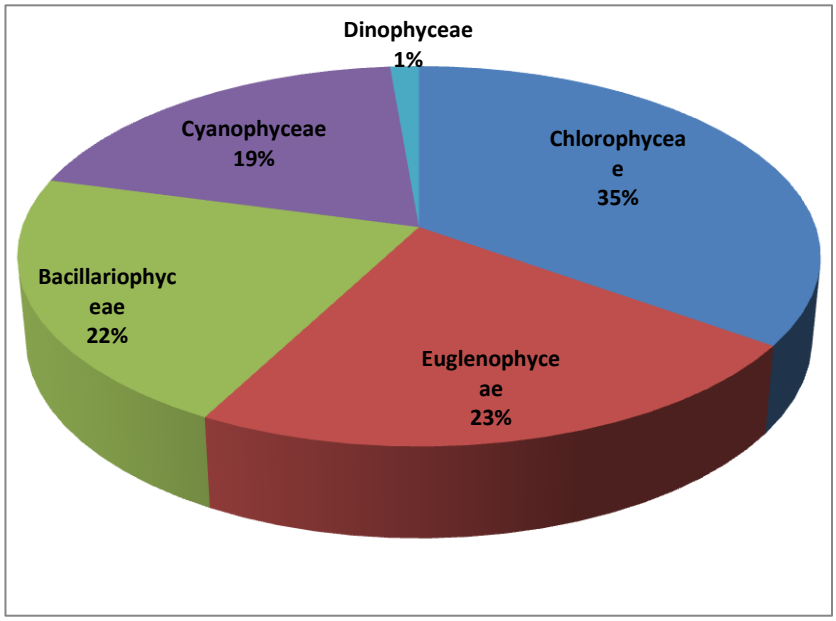


Fig 85: Diversity of Phytoplankton during November 2011

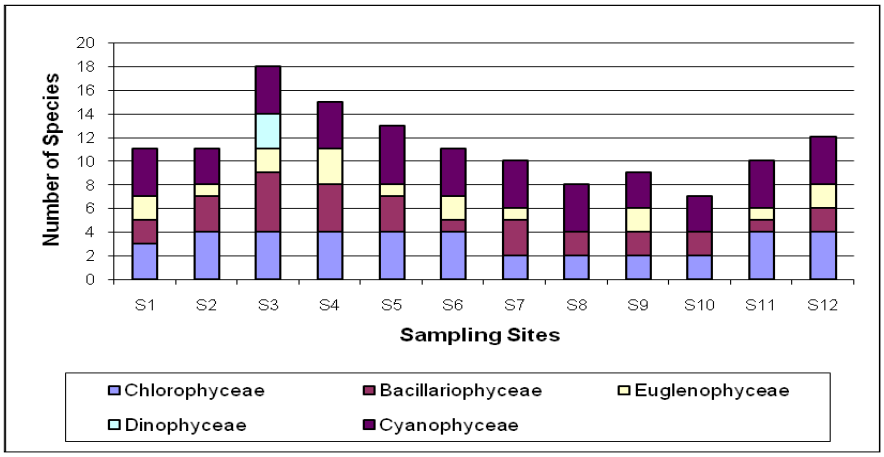


Fig 86: Density of Phytoplankton during November 2011

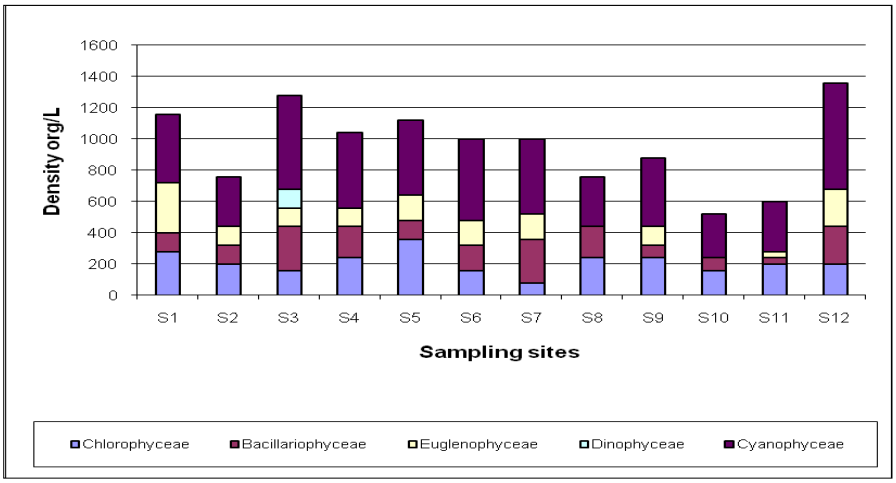


Fig 87: Diversity of Phytoplankton during December 2011

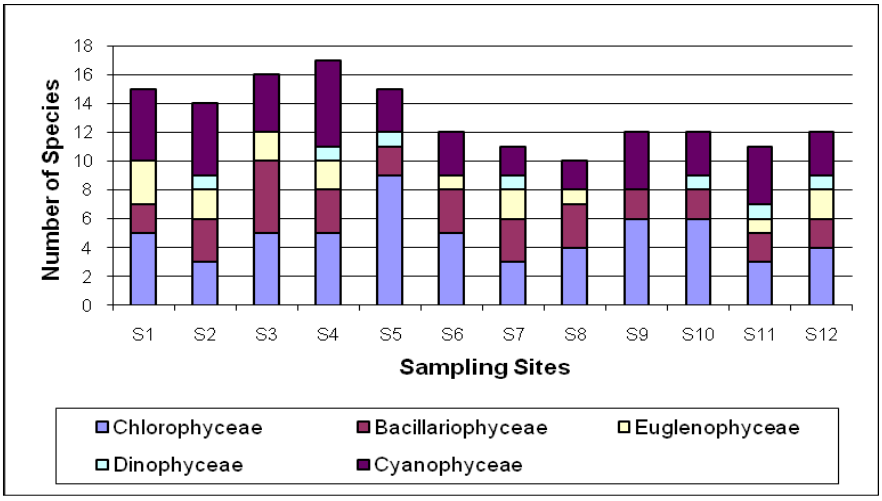


Fig 88: Density of Phytoplankton during December 2011

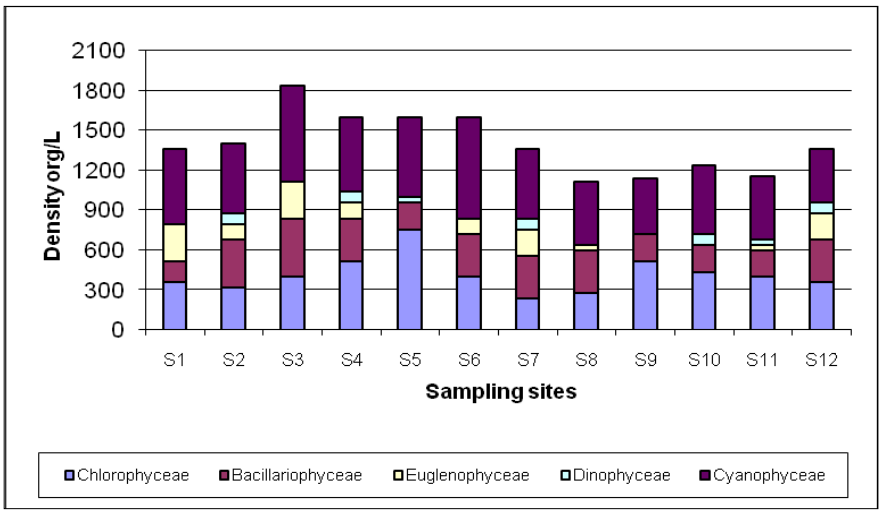


Fig 89: Diversity of Phytoplankton during January 2012

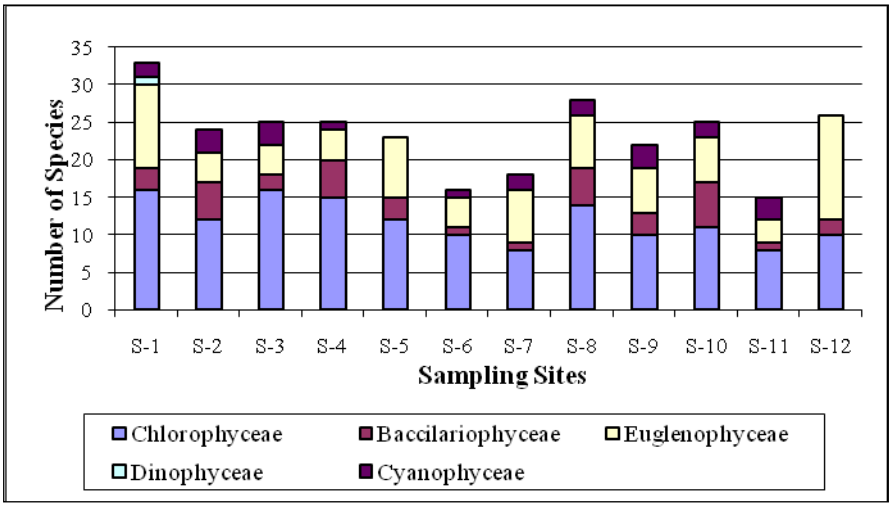


Fig 90: Density of Phytoplankton during January 2012

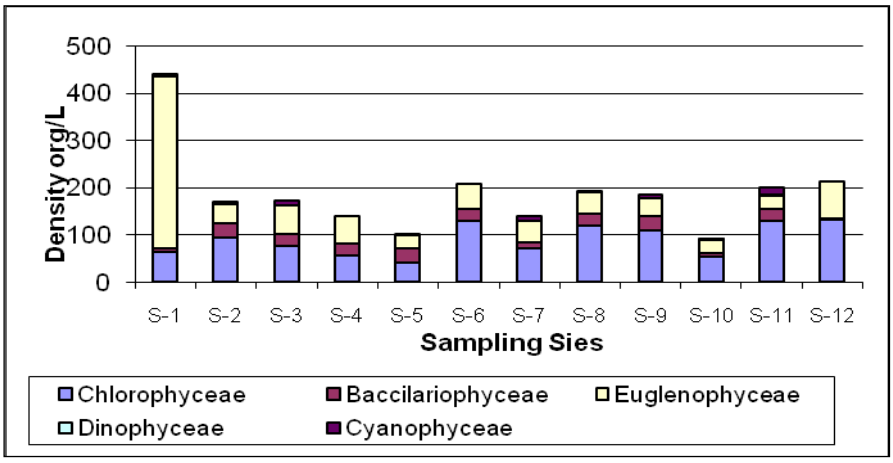


Fig 91: Diversity of Phytoplankton during February 2012

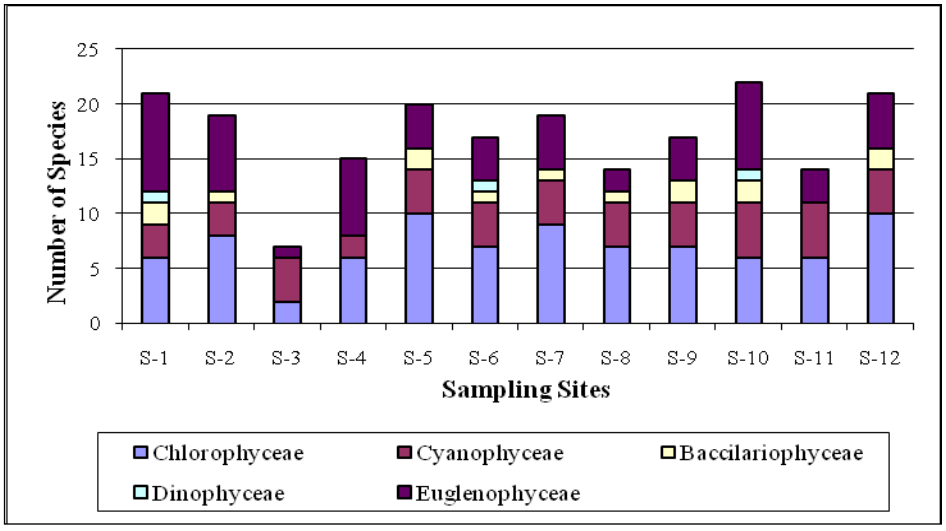


Fig 92: Density of Phytoplankton during February 2012

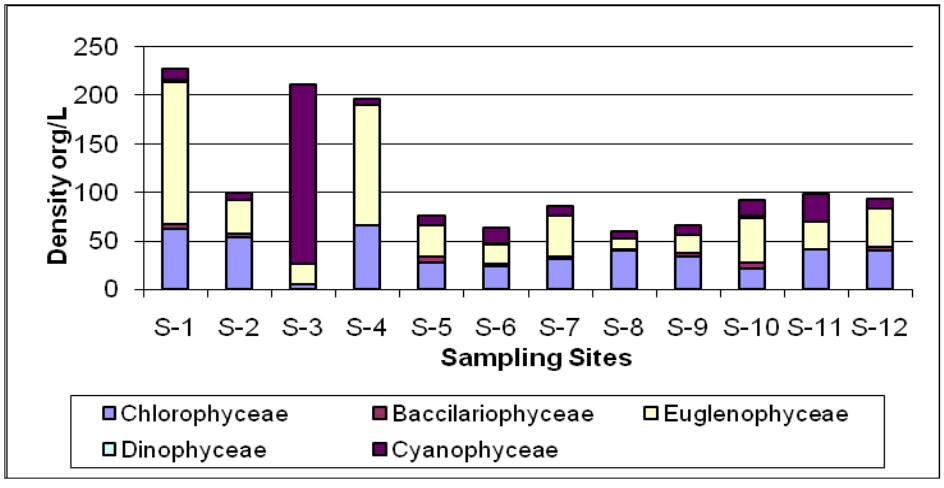


Fig 93: Diversity of Phytoplankton during March 2012

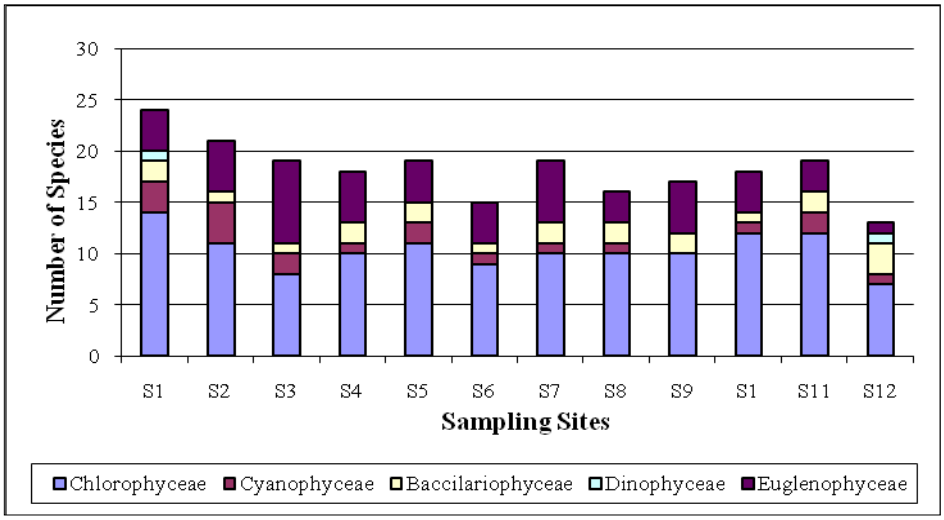


Fig 94: Density of Phytoplankton during March 2012

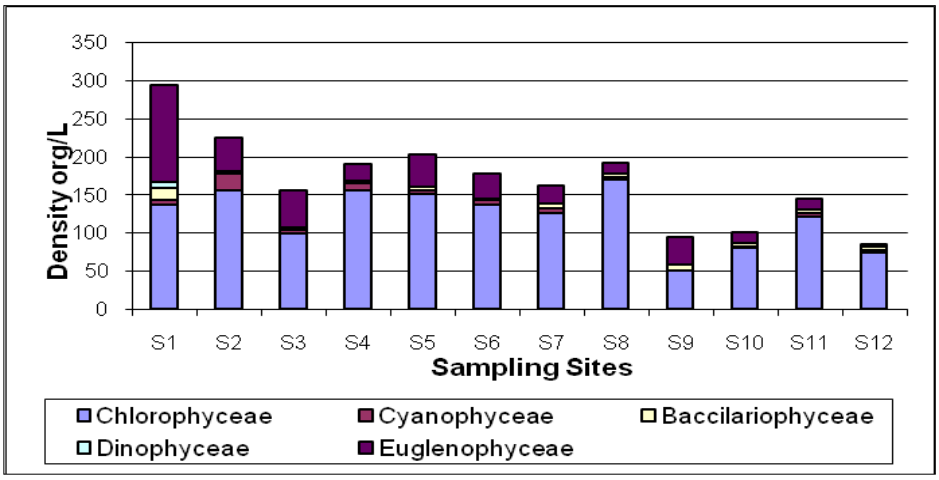


Fig 95: Diversity of Phytoplankton during April 2012

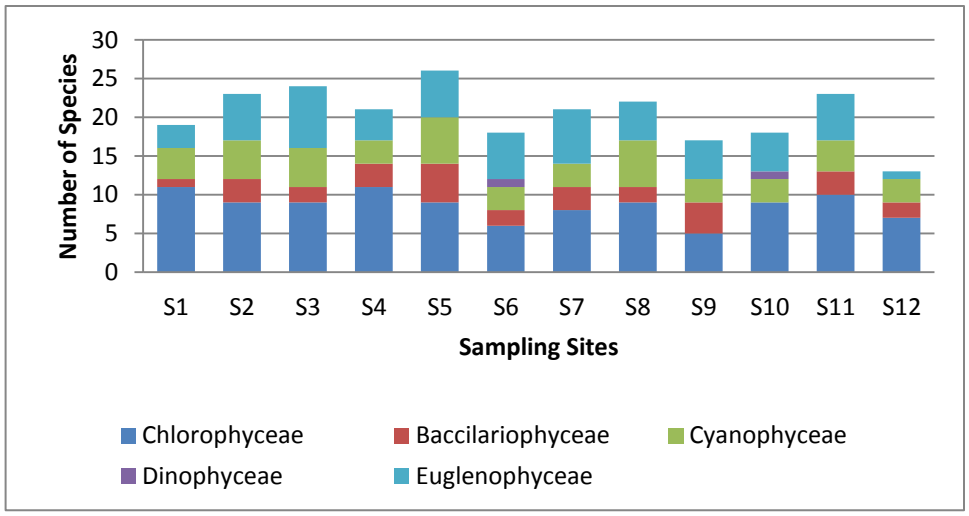


Fig 96: Density of Phytoplankton during April 2012

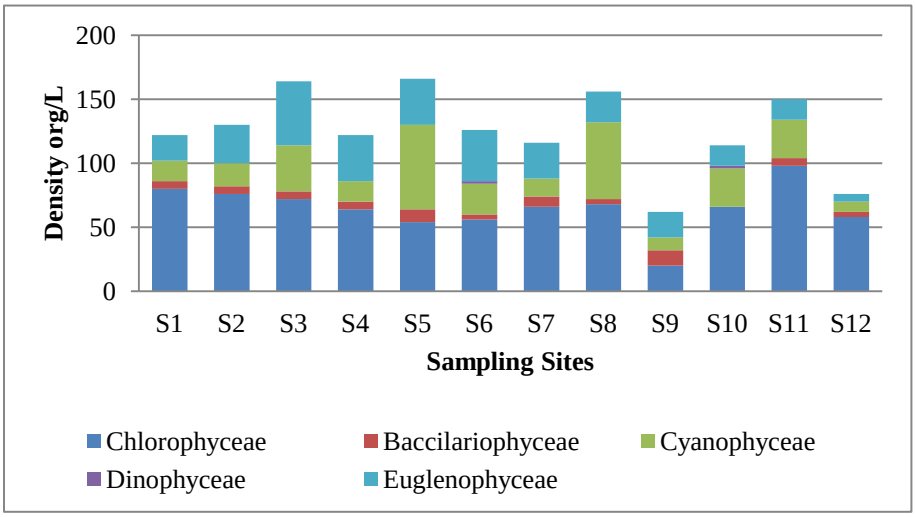


Fig 97: Diversity of Phytoplankton during May2012

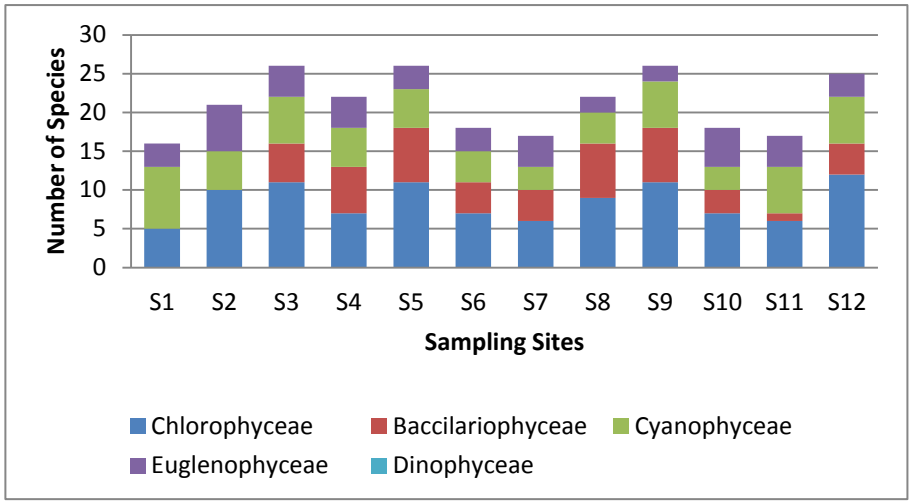


Fig 98: Density of Phytoplankton during May 2012

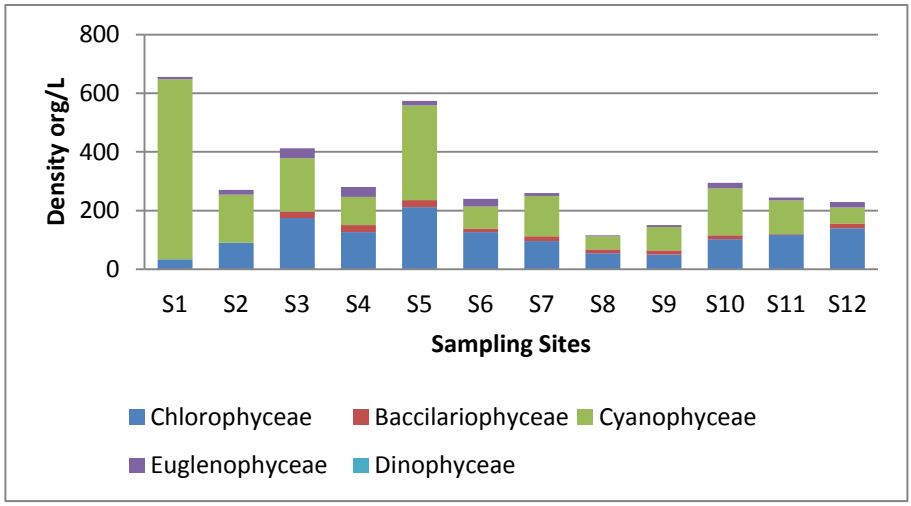


Fig 99: Diversity of Phytoplankton during June2012

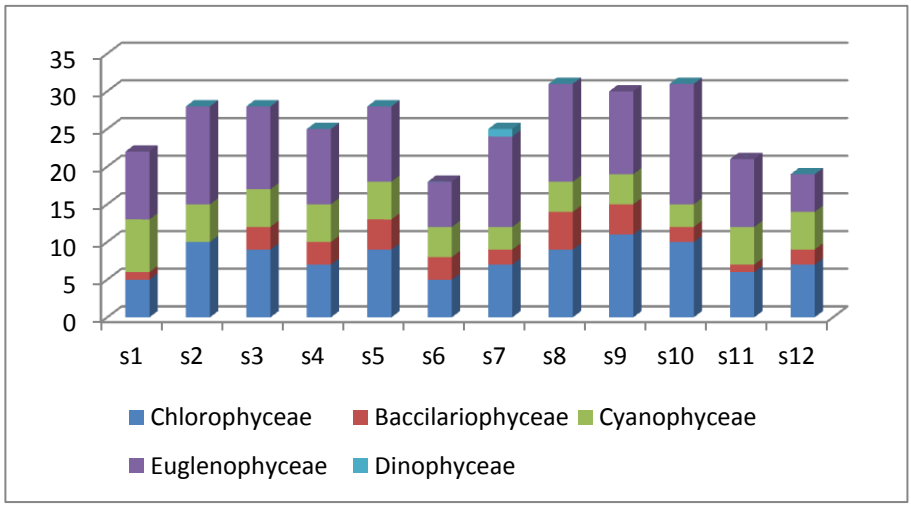


Fig 100: Density of Phytoplankton in the month of June 2012

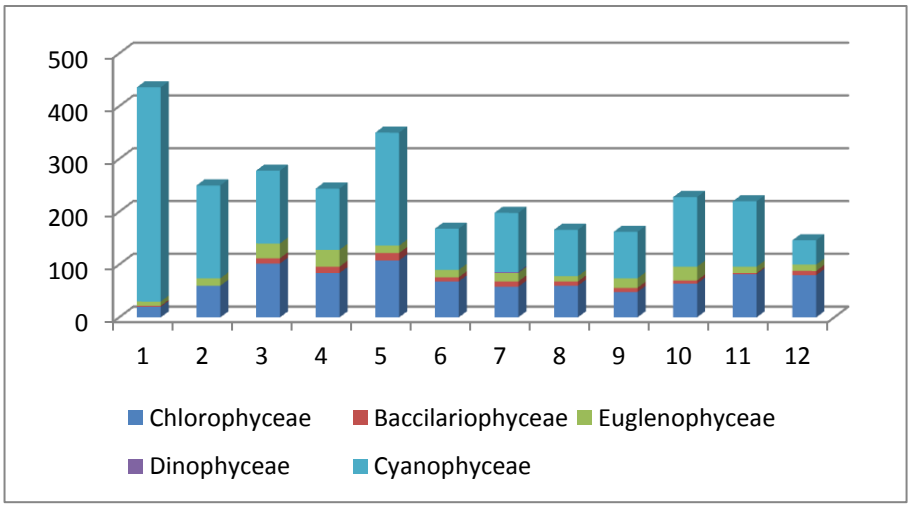


Fig 101: Diversity of Phytoplankton in July 2012.

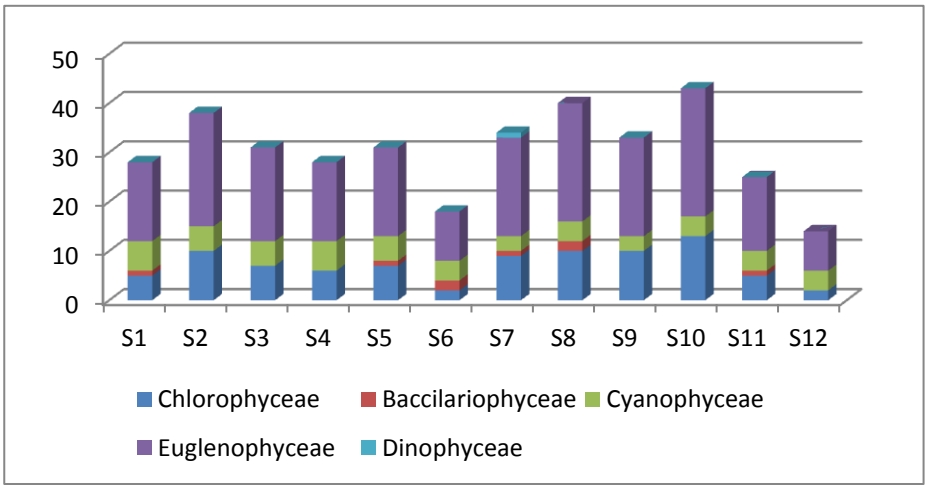


Fig 102: Density of Phytoplankton in July 2012.

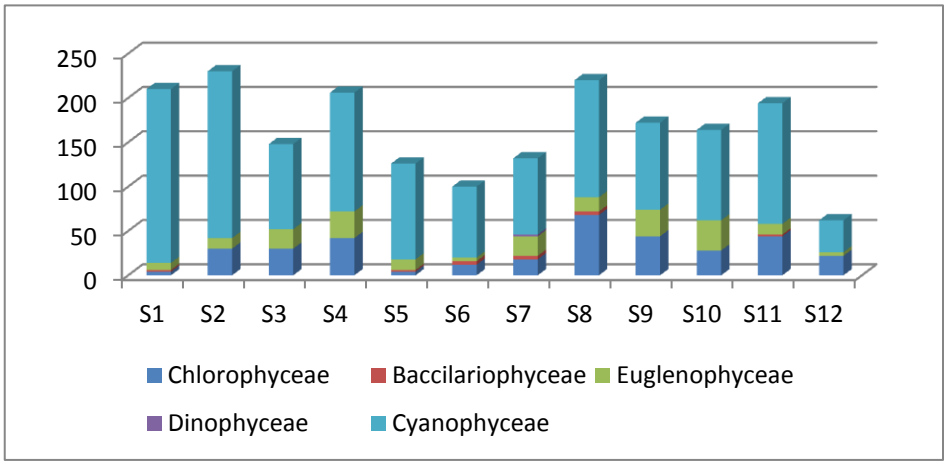


Fig 103: Diversity of phytoplankton in September 2012

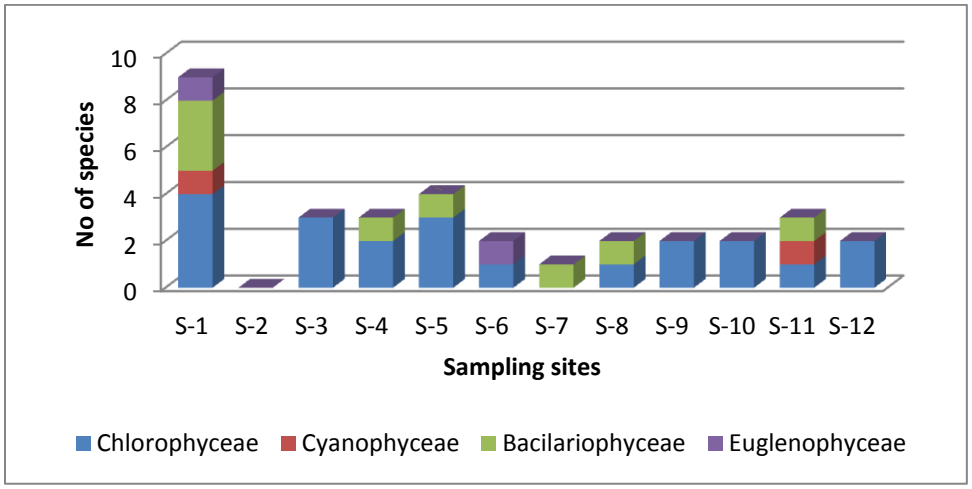


Fig 104: Density of phytoplankton in September 2012

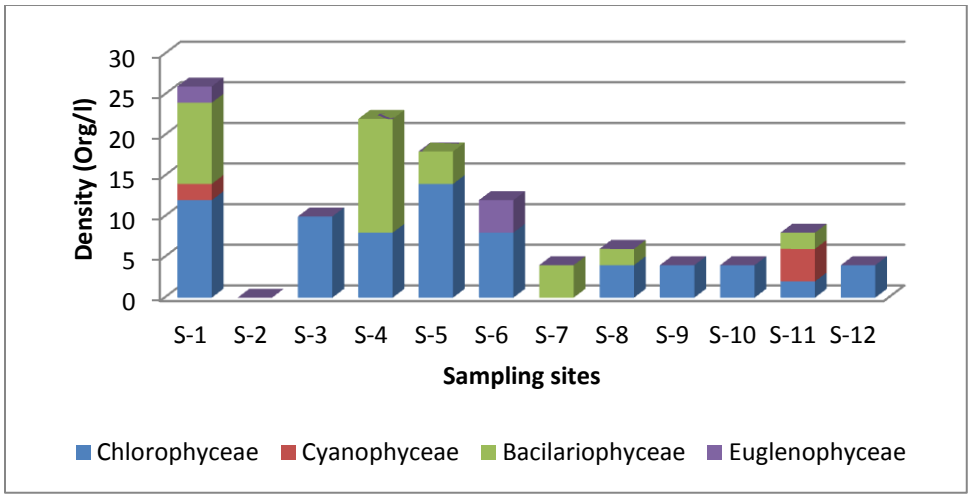


Fig 105: Diversity of phytoplankton in October 2012

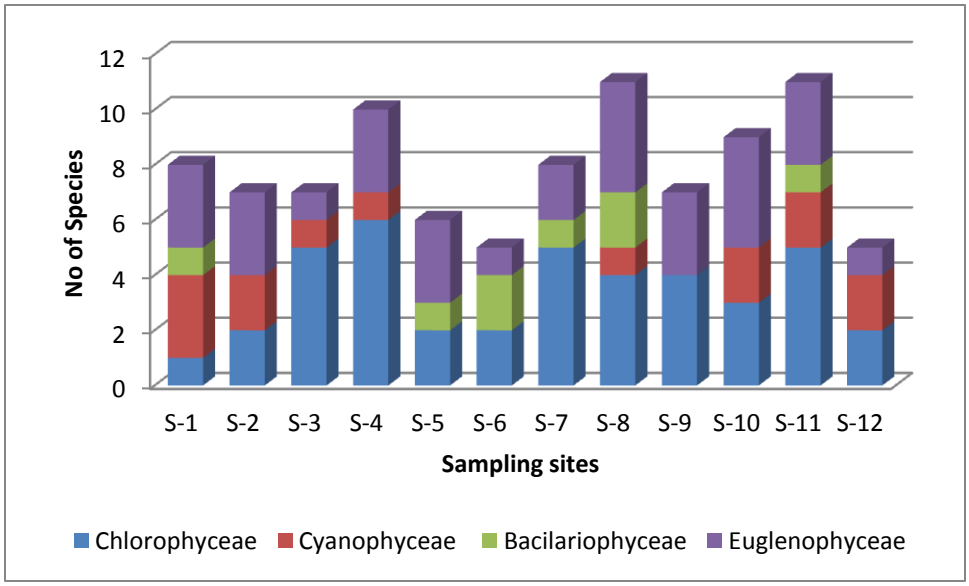


Fig 106: Density of phytoplankton in October 2012

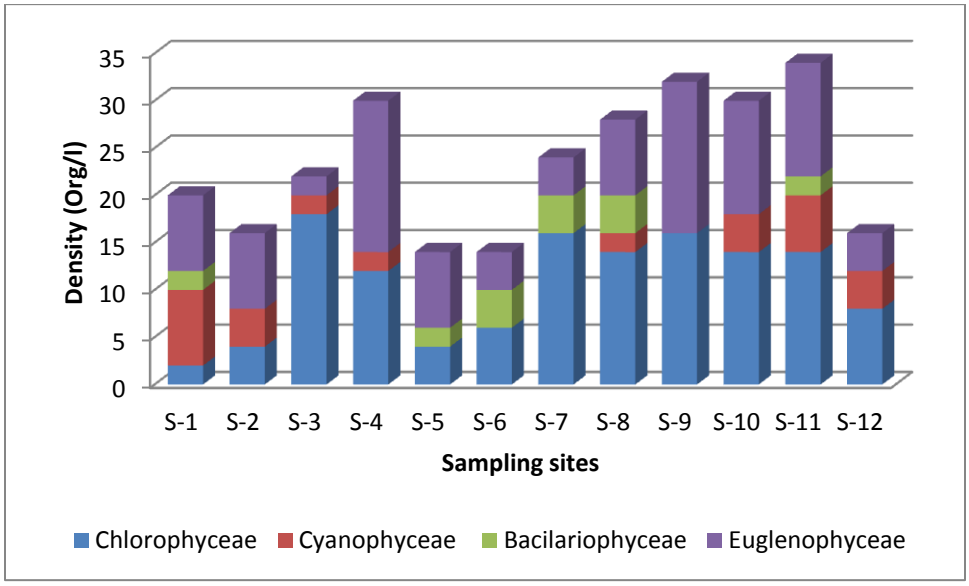


Table 14: List of phytoplankton diversity in Shahpura lake from November 2011 to Oct. 2012.

	SPECEIS	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
GROUPS : CHLOROPHYCEAE													
1	*Actinastrum hatztchii*	+	+	+	+	+	+	+	+	+	+	+	+
2	*A. convatus*	+	+	+	+	-	-	-	-	-	+	-	-
3	*Ankistrodesmus falcatus*	+	+	+	-	+	+	+	+	-	+	+	+
4	*A.spiralis*	+	+	+	+	+	+	+	+	+	+	+	-
5	*Cheatophora*	+	-	-	-	+	-	-	-	-	-	-	+
6	*Cladophora*	+	+	+	-	-	+	+	+	-	-	+	+
7	*Closteriopsis sp,*	+	+	+	+	+	+	+	+	+	+	+	+
8	*C.longissilene*	+	-	-	-	-	-	-	-	-	-	-	-
9	*Closterium acerosum*	-	-	-	-	-	-	-	-	-	-	-	+
10	*C. microsporum*	-	-	-	+	-	-	-	-	-	-	-	-
11	*C. psephonema*	-	-	-	+	-	-	-	-	-	-	-	-
12	*C. purvulum*	+	+	+	+	+	+	+	+	+	+	+	+
13	*Closteridium siamensis*	+	-	-	+	-	-	-	-	+	-	-	-
14	*C.acutum*	-	-	-	-	-	-	-	-	+	-	-	+
15	*Coelestrum*	-	+	-	-	-	-	+	-	-	-	-	-
16	*Crusigenia*	-	-	-	+	-	-	-	+	+	-	-	-
17	*Echinospaerella limnetica*	+	-	-	-	+	-	+	-	+	+	+	-
18	*Elakothorix sp.*	-	-	-	-	+	-	-	-	+	-	-	+
19	*Euddorina sp.*	+	-	-	-	-	-	-	-	-	-	-	-
20	*Gonium sp.*	+	-	-	-	-	-	-	-	-	-	-	-
21	*Microspora sp.*	-	+	+	+	-	+	-	-	+	-	-	+
22	*Microsporum sp.*	+	-	-	-	-	-	-	+	-	-	+	-
23	*Mictactinium sp.*	+	-	-	-	-	-	-	-	-	-	-	-
24	*Nitrium sp.*	-	-	-	-	-	-	-	-	-	+	-	+
25	*Pediastrum sp.*	+	+	+	-	+	+	+	+	+	+	+	+
26	*P. biradiatum*	-	+	+	-	+	-	+	+	+	-	+	+
27	*P. duplex*	+	+	+	+	+	+	+	-	+	+	+	+
28	*P. ovatum*	-	+	-	-	+	-	-	-	+	-	-	-
29	*P. tetras*	-	-	-	-	-	-	+	-	-	-	+	-
30	*P. simplex*	+	+	+	+	-	-	-	-	-	+	+	+
31	*salenastrum bibraiano*	-	-	-	-	-	-	-	+	-	-	-	-
32	*S. minutes*	-	-	-	-	-	-	-	+	-	-	-	+
33	*Scendesmus acuminatus*	+	-	-	+	-	+	-	+	-	-	-	+
34	*S. armatus*	+	+	+	+	+	+	+	+	+	+	+	+
35	*S. bijugatus*	+	+	+	+	+	+	+	+	+	+	+	+
36	*S. carinatus*	+	+	-	-	+	+	-	-	-	+	-	-

	SPECEIS	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
37	*S. dimorphus*	+	+	+	+	+	+	+	+	+	+	+	+
38	*S. hermardi*	-	-	-	+	-	-	-	+	-	-	-	-
39	*S. longsvar*	-	-	-	-	+	-	-	-	-	-	-	-
40	*S. oblique*	+	+	+	+	+	-	-	-	+	+	-	+
41	*S. protuberans*	+	-	-	+	+	+	-	-	-	-	-	-
42	*S. quadricanda*	+	-	-	+	-	-	-	+	-	-	-	+
43	*Schroederia setigera*	+	-	-	-	-	-	-	-	-	-	-	-
44	*Spyrogyra sp.*	+	-	+	-	-	+	-	-	-	-	-	-
45	*Tetradron trigonum*	+	+	+	+	+	+	+	+	+	+	+	+
46	*T.prolieforme*	-	-	-	+	-	-	-	-	-	-	-	-
47	*T.quadratum*	-	+	+	+	-	-	-	+	-	-	-	-
48	*Tetrastrum sp.*	-	-	-	+	-	-	-	-	-	-	-	-
49	*Triptoceros sp.*	-	+	-	-	-	-	-	-	-	-	-	-
50	*Ulothrix sp.*	+	-	-	-	-	-	+	+	-	-	-	+
51	*uronema sp.*	-	-	+	+	-	-	-	-	-	-	-	+
52	*volvox sp.*	-	-	+	-	-	-	-	-	-	-	-	+
53	*Zygnema sp.*	-	-	-	-	-	-	-	-	-	+	-	+
GROUP: CYNOPHYCEAE													
54	*Anabaena circinalis*	+	+	+	+	+	+	+	+	+	+	+	+
55	*A. utermohlii*	+	+	+	+	-	+	-	+	+	+	+	-
56	*Anamoesis sp.*	-	-	+	-	-	-	-	-	-	-	-	-
57	*A.navicoloid*	-	-	-	+	-	-	-	-	-	-	-	-
58	*Anabaenopsis arnoldii*	+	+	+	+	+	+	+	-	+	-	-	+
59	*A. syhaerophora*	-	-	-	-	-	-	-	-	-	-	+	-
60	*Arthrospira platensis*	+	+	+	+	+	+	+	+	+	+	+	+
61	*A. massartii*	+	+	+	+	+	+	+	+	-	-	-	-
62	*chroococus turgidis*	+	-	-	-	-	-	-	-	-	-	-	+
63	*Lygbea borgeri*	+	+	+	+	-	-	+	+	-	-	+	+
64	*L. limnatica*	-	-	+	-	+	-	+	-	+	+	-	-
65	*Microsystis sp.*	-	-	-	-	-	-	-	-	-	-	-	-
66	*Oscillatoria sp.*	+	-	+	-	-	-	-	+	+	-	+	+
67	*O. Amphibia*	+	-	-	-	+	-	-	-	-	+	-	-
68	*O. animalis*	-	+	-	+	-	+	+	-	-	+	+	-
69	*O. amphigranulata*	-	-	-	-	-	-	-	-	-	-	+	-
70	*O. chalybea*	+	-	-	-	-	-	-	+	-	-	-	-
71	*O. prolific*	-	-	-	-	+	-	-	-	-	-	-	+
72	*Osystis sp.*	-	-	-	-	-	-	-	-	-	-	+	-
73	*Ouroococus bicaudata*	+	+	+	+	+	+	-	+	+	+	+	-
74	*Phormidium teneu*	-	-	+	-	-	-	+	-	+	-	-	+

75	*Rhaphidiopsis sp.*	-	+	-	-	-	-	-	-	-	-	-	-
76	*Rhaphidiopsis medeterina*	+	+	+	+	+	+	+	+	+	+	+	+
77	*Spirulina indica*	-	-	-	-	-	-	-	+	-	-	-	+
78	*spirulina sp.*	+	+	+	-	+	+	+	+	+	-	+	-
79	*S. labirinthisformis*	-	+	+	-	-	+	-	-	+	-	+	-
80	*S. subtilisima*	-	-	+	-	+	-	-	+	-	-	+	-
81	*S.indica*	-	-	+	-	+	-	-	+	-	-	+	-
82	*S. laxissima*	+	-	-	-	+	-	-	+	-	-	-	-
GROUP: BASCILLARIOPHYCEAE													
83	*Achnanthas lanceolatum*	-	-	-	-	-	-	-	-	-	-	+	-
84	*A. minutisma*	-	+	+	-	-	-	-	-	-	-	-	-
85	*Amphora sp.*	-	-	-	-	-	+	-	-	+	+	-	-
86	*A. minutissima*	+	-	-	-	-	-	-	-	-	-	-	-
87	*A. ovalis*	-	-	-	-	-	-	-	-	-	-	+	-
88	*A. microcephala*	-	-	-	+	-	-	-	-	+	-	-	-
89	*A.Navicullasiss*	+	-	-	-	-	-	-	-	-	+	-	+
90	*Cymbella officinalus*	-	-	-	-	-	-	-	-	-	-	+	-
91	*Cyclotella stelligera*	-	-	-	-	-	+	-	-	-	+	-	-
92	*Fragillaria rumpse*	-	-	-	-	+	-	-	+	+	-	-	-
93	*F. intermedia*	-	-	-	-	-	-	+	-	-	-	-	+
94	*Frustullia sp.*	+	-	-	-	-	+	-	+	+	+	-	-
95	*Gomphonema sp.*	-	-	+	-	+	+	+	+	+	+	-	-
96	*G. sphaerophorum*	-	-	+	-	-	-	-	-	+	-	-	-
97	*G. instricatum*	+	+	-	+	+	+	+	+	+	+	+	+
98	*G. lenceolatum*	-	-	-	+	-	+	-	-	+	-	-	-
99	*G.montanum*	-	-	+	-	+	-	-	+	-	-	-	+
100	*Melosira sp.*	-	-	-	-	+	-	-	+	-	-	-	-
101	*M. granulate*	-	+	+	+	-	-	-	-	+	-	-	-
102	*Navicula sp.*	-	+	+	+	+	+	+	-	-	-	-	-
103	*N. hallophila*	-	+	+	-	+	-	-	+	-	-	-	-
104	*N. confovoce*	-	-	-	-	-	-	-	+	-	-	-	-
105	*N. grimmil*	+	+	-	+	-	-	-	-	-	-	-	-
106	*N. subrhyncocephola*	+	-	-	-	-	-	-	-	-	-	-	+
107	*Netrium sp.*	+	-	-	-	-	-	-	-	-	-	-	-
108	*Nitzchia sp.*	-	+	-	+	-	-	+	+	-	-	+	+
109	*N. palae*	-	+	-	-	+	+	-	+	-	+	+	-
110	*N. amphibian*	-	-	-	-	-	-	-	+	-	-	+	-
111	*N. cryptocephala*	-	-	-	-	+	-	-	-	+	-	-	-
112	*Synedra sp.*	-	-	+	+	+	-	-	+	-	-	+	+
113	*S. rumpes*	+	-	+	+	+	+	+	-	+	-	-	-

	SPECEIS	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
GROUP:DINOPHYCEAE													
115	*Ceratium sp.*	+	-	-	-	-	+	+	-	-	+	+	-
116	*Dinobryon sp.*	+	-	-	-	-	-	-	-	-	-	-	+
GROUP:EUGLENOPHYCEAE													
117	*Clamydomonas sp.*	-	-	+	-	-	-	-	-	-	-	-	-
118	*Euglena sp.*	+	-	+	-	+	+	+	+	-	+	+	-
119	*E. acus*	+	+	+	+	+	+	+	+	+	+	-	+
120	*E. allorgei defl*	+	+	+	+	+	+	+	+	+	+	+	+
121	*E. candata*	-	-	-	-	-	-	-	-	-	+	-	-
122	*E. elastic*	+	-	-	-	-	-	-	-	-	-	-	+
123	*E. gracillis klebs*	+	+	+	+	+	+	+	+	+	+	+	+
124	*E. ignobilis*	+	-	-	-	-	-	-	-	-	-	-	+
125	*E. limnophila*	+	+	+	-	-	-	+	+	+	-	+	-
126	*E. proxima danegeraede*	+	-	-	-	-	-	+	-	-	-	-	-
127	*E. salina*	-	+	-	+	-	-	-	-	-	-	-	-
128	*E. srinagari*	+	-	-	-	-	-	-	-	-	+	-	+
129	*E. vogans*	+	+	+	+	+	+	+	+	+	+	+	+
130	*Eugleno morpha*	+	+	+	+	+	+	+	+	+	+	+	+
131	*E.pisciformis*	-	-	+	-	-	-	-	-	-	-	-	-
132	*Lepocinalis sp.*	-	-	-	-	-	-	+	-	-	-	+	-
133	*L. fourmis*	-	-	-	-	-	-	-	+	-	-	-	-
134	*L. marssonii*	-	-	-	+	-	-	-	-	-	-	-	-
135	*L. salina*	-	-	+	-	-	+	-	+	-	-	-	-
136	*Phacus sp.*	+	+	+	+	+	+	+	+	+	+	+	+
137	*P. acuminatus*	+	+	+	+	+	+	+	+	+	+	+	+
138	*P. agilis*	-	-	-	-	-	-	-	-	-	-	-	-
139	*P. brachykentron*	-	-	-	+	-	-	+	-	-	-	-	-
140	*P. corviconda*	-	+	-	-	-	-	-	-	-	-	-	-
141	*P. candata*	-	+	+	-	-	-	-	-	-	-	-	-
142	*P. inflatus*	-	-	-	-	-	-	-	+	-	-	-	-
143	*P. platala*	+	-	-	-	-	-	-	-	-	-	-	-
144	*P. tortus*	+	-	+	-	-	-	-	-	-	+	-	-
145	*P. wettsteni*	+	-	-	-	-	-	-	-	-	+	-	-
146	*Schorderia planktonika*	+	-	-	-	-	-	-	-	-	-	-	-
147	*S. indica*	-	-	-	+	-	-	-	-	-	-	-	-
148	*Strombomonas gerardiana*	-	-	-	-	-	+	-	-	-	-	-	-
149	*S. ovalis*	+	-	-	-	-	-	-	-	+	+	-	-
150	*Trecheloman bulla*	-	+	-	-	-	-	-	-	-	-	-	-

b. Zooplankton:

In Shahpura lake total 62 zooplankton species were recorded belonging to 6 groups (Protozoa, Rotifera, Cladocera, Copepoda, Osracoda, and Cyclopida). Group Rotifera was the highest number of species (43 species) followed by Protozoa (6 species), Cladocera (5 species), Copepoda and Cyclopoida (3 species) and 1 species of Ostracoda. The zooplankton diversity of Shahpural lake was varied between 14 species at site 10 to 27 species at site 8 during the study period. The maximum number of species were recorded in January month which was 36 species where as minimum zooplankton diversity of 9 species were recorded in September. The total zooplankton density of Shahpura lake varied between 6 to 234 organisms/l. The highest density of zooplankton were recorded in the month of May 234 organisms/l at site-8 and lowest density of zooplankton was recorded 6 organisms/l at site-10 in the month of January and September.

Group wise spatial and temporal variation of zooplanktons:

Rotifera:
A total 43 species of Rotifera group were recorded during the study period. Rotifera group maximum zooplankton diversity showed in January with 34 species and minimum in September with 7 species. The maximum diversity 10 was recorded at site 1 in the month of January and minimum 1 species was recorded at site 12 in the month of September. Density of Rotifera group was varied between minimum 8 organisms/l at site 1 in the month of January to maximum 48 organisms/l at site 12 in the month of September.

Cladocera:
A total 5 species of Cladocera group were recorded during the study period. Cladocera group showed maximum zooplankton diversity recorded in January with 5 species and 1 species was recorded in February and October. Group Cladocera was not found in the month of March, April, May June, July and September. In spatial case this group showed maximum diversity of 3 species at site 2 and minimum 1 species at site 6, site 7 and site11. Density of Cladocera group was found 6 organisms/l at site 2 in February and site 6 shows lowest density 2 organisms/l in January during present study.

Protozoa:
A total 6 species of Protozoa group were recorded during the study period. Protozoa group recorded maximum zooplankton diversity in January with 5 species and minimum was 1 species in the month of February, April and September. This group showed maximum diversity of 2 species at site 8, site 11 and site 12 and minimum 1 species at site 1, site 5 and site 7. The density of Protozoa group was varied between 2 to 10 organisms/l. The maximum density of Protozoa 10 organisms/l was recorded at site 11 in the month of January.

Copepoda:

A total 3 species of Copepoda group were recorded during the study period. Copepod group shows maximum zooplankton diversity with 3 species recorded at site 5 and minimum diversity of 1 species was recorded at site 1, site 2, site 8 and site 11. This group was absent during the entire study period at site 3, site 4 site 6, site 7, site 10 and site 12. This group highest density showed 32 organisms/l at site 12 in the month of January and 6 organisms/l at site 10 in the month of January and October.

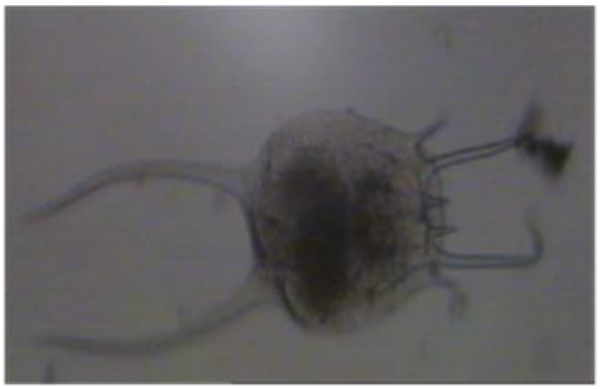
Cyclopoida:

A total 3 species of Ccyclopoda group were recorded during the study period. The maximum diversity of Cyclopoida group recorded 3 species ant site 8 and minimum 1 species recorded at site 2, site 3, site 4, site 7, site 11 and site 12 during the study period. The highest density of Cyclopoida group was found 58 organisms/l recorded at site 1 in February and lowest density 8 organisms/l at site 2 were recorded during present study.

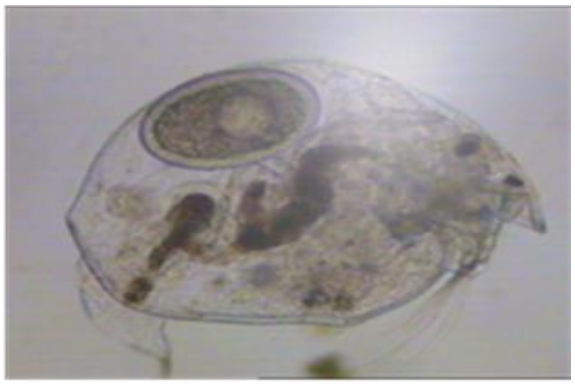
Ostracoda:

In Ostracoda group only one *Cypris sp*. was recorded at site 12 in December 2011 and January 2012 months. This group was not found after January month during the study period.

Plate-II : photographs of zooplankton in Shahpura lake



. *Brachionus falcatus*

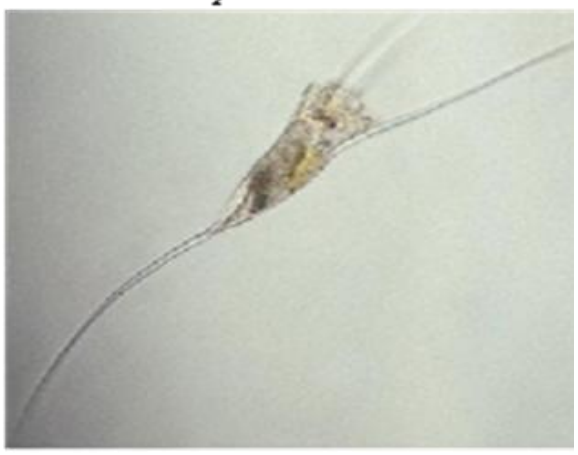


Ceriodaphnia sp.

Lecane sp.

Diaptomus

. *Brachionus sp.*



Kellicottia

Fig 107: Percentage composition of zooplanktons in Shahpura lake

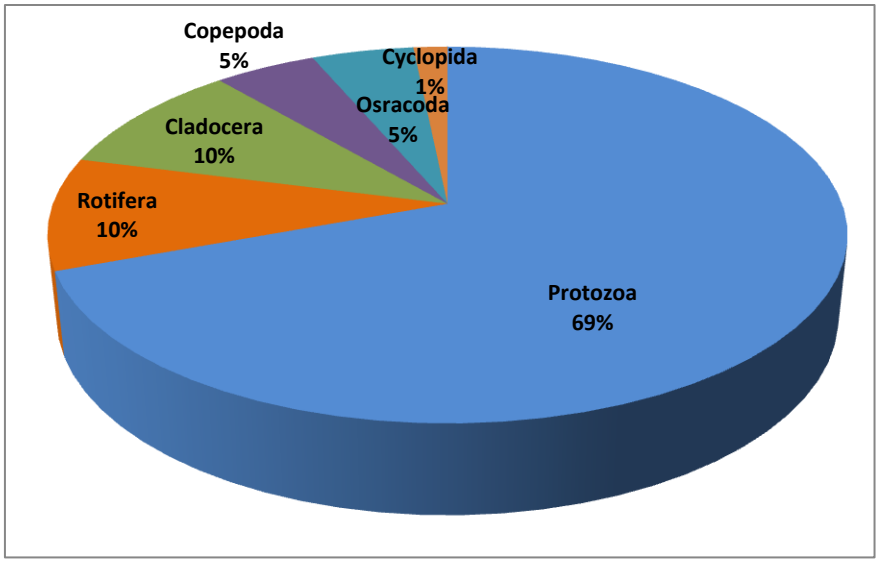


Fig 108: Diversity of Zooplankton during November 2011

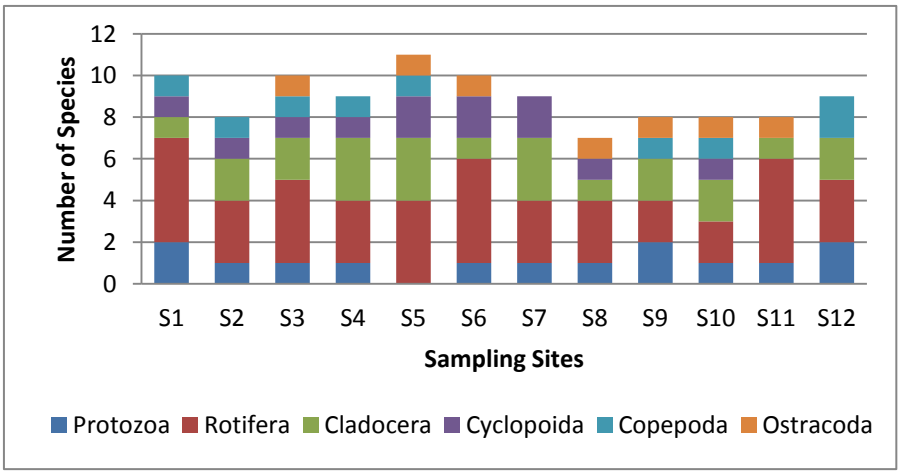


Fig 109: Density of Zooplankton during November 2011

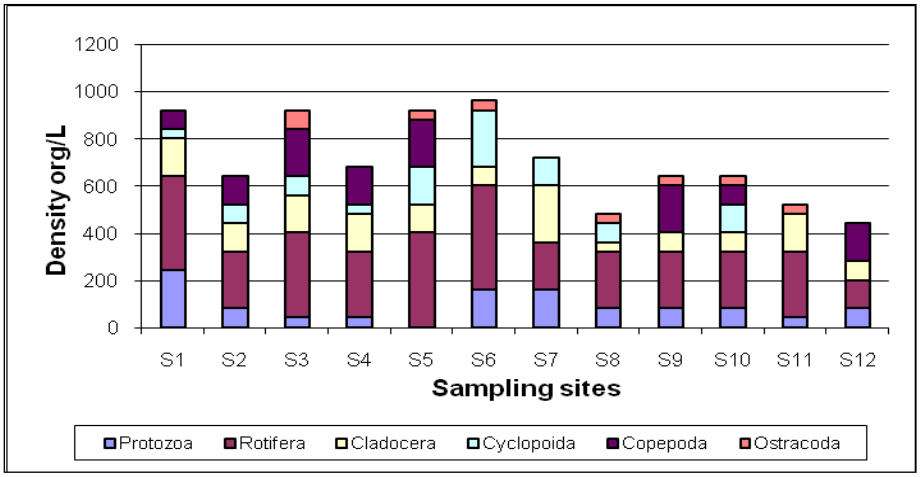


Fig 110: Diversity of Zooplankton during December 2011

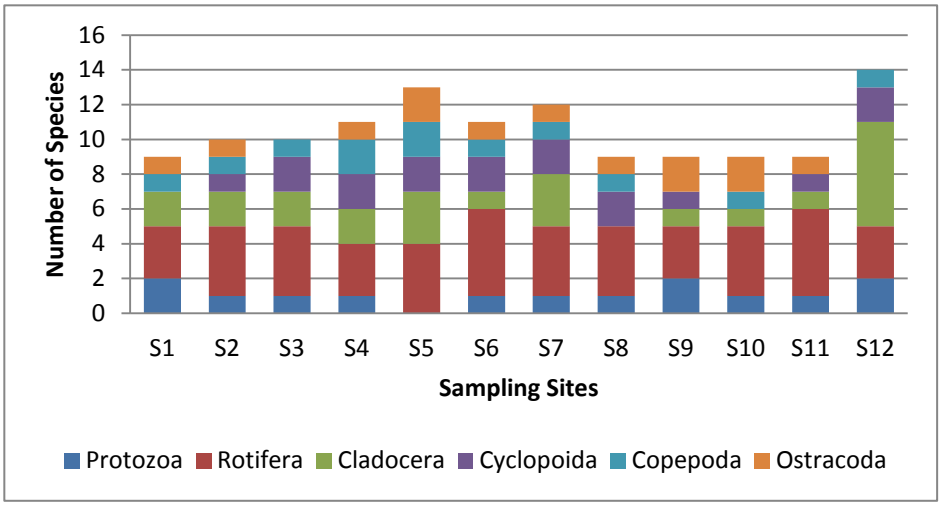


Fig 111: Density of Zooplankton during December 2011

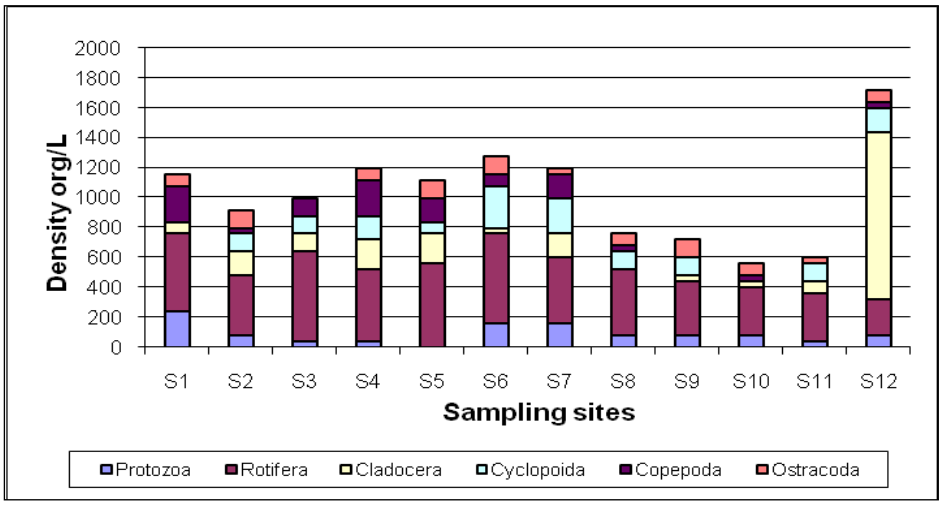


Fig 112: Diversity of Zooplankton during January 2012

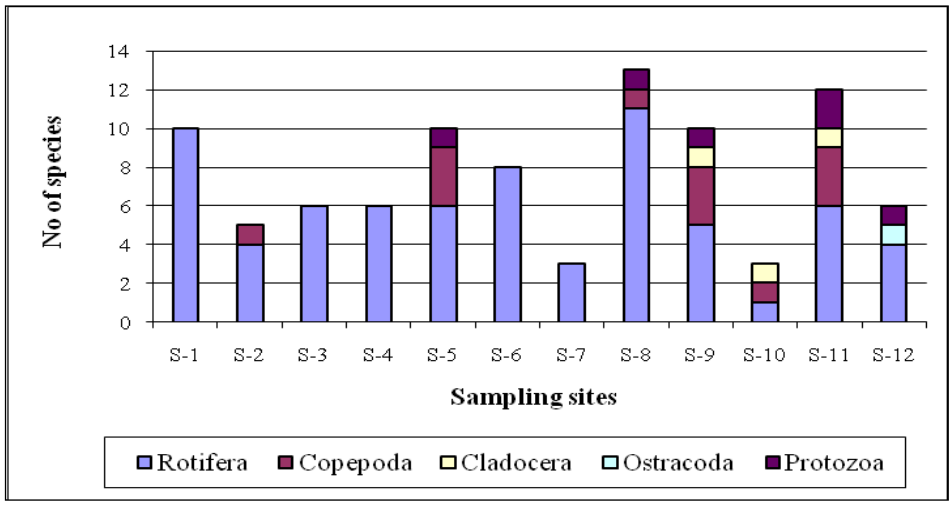


Fig 113: Density of Zooplankton during January 2012

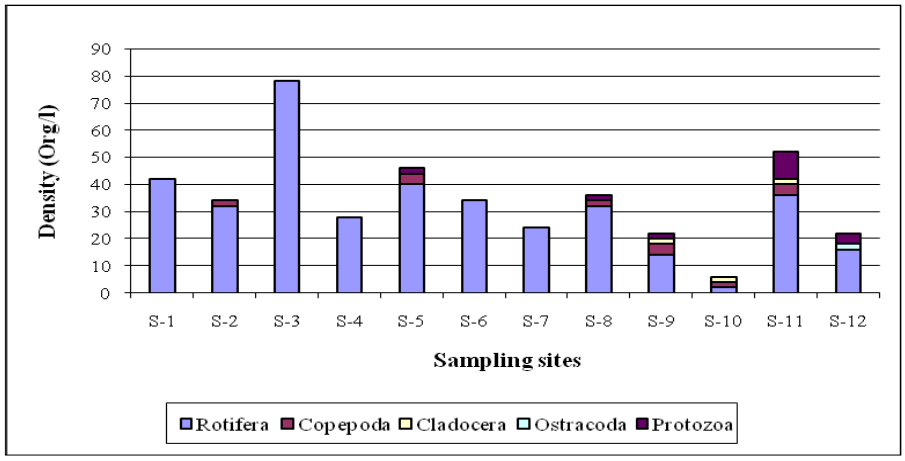


Fig 114: Diversity of Zooplankton during February 2012

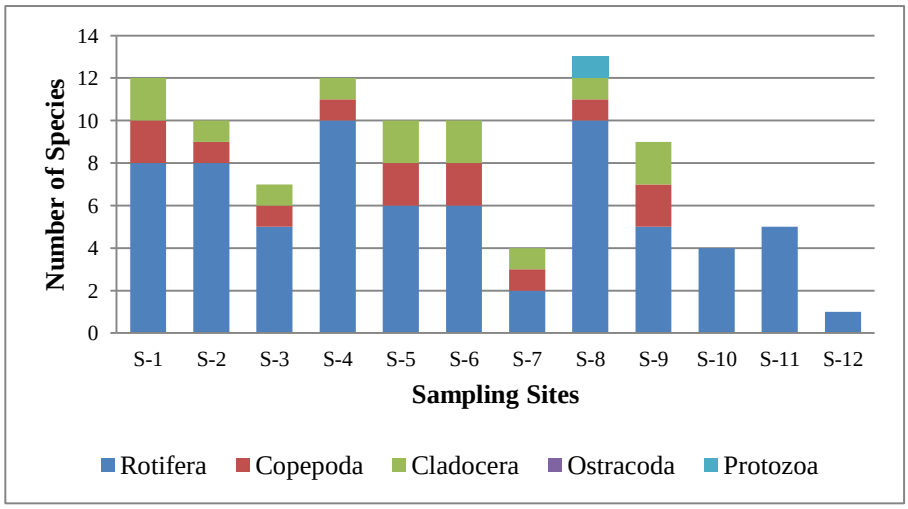


Fig 115: Density of Zooplankton during February 2012

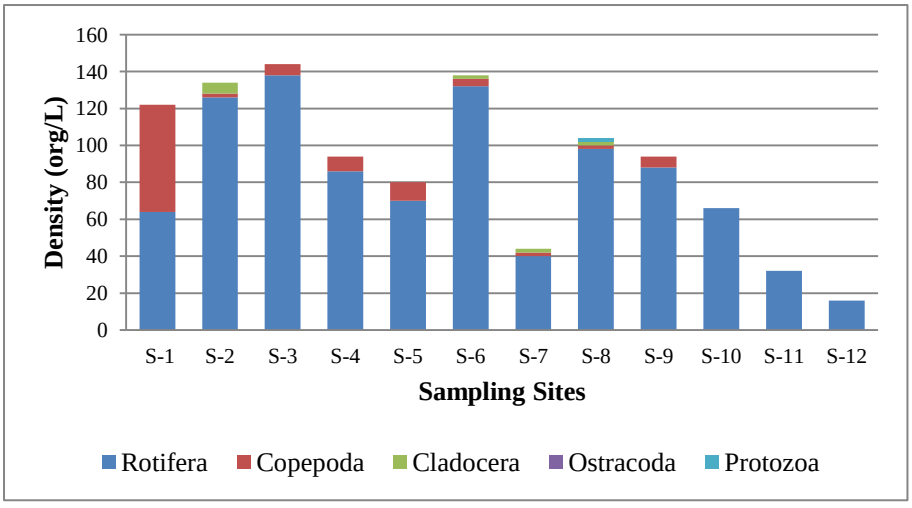


Fig 116: Diversity of Zooplankton during March 2012

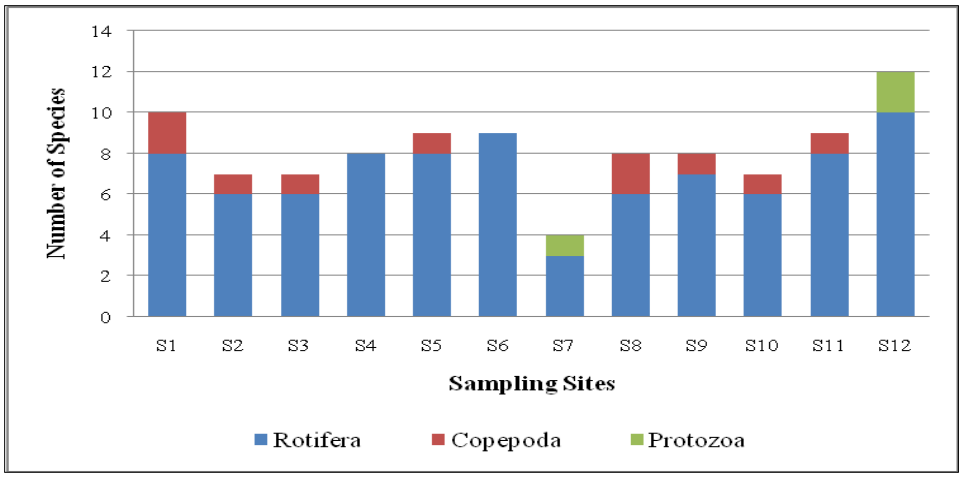


Fig 117: Density of Zooplankton during March 2012

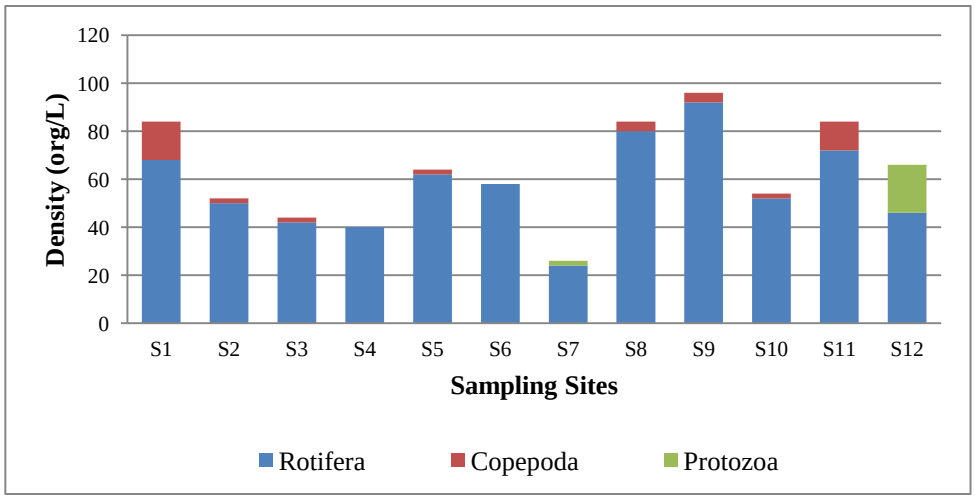


Fig 118: Diversity of Zooplankton during April 2012

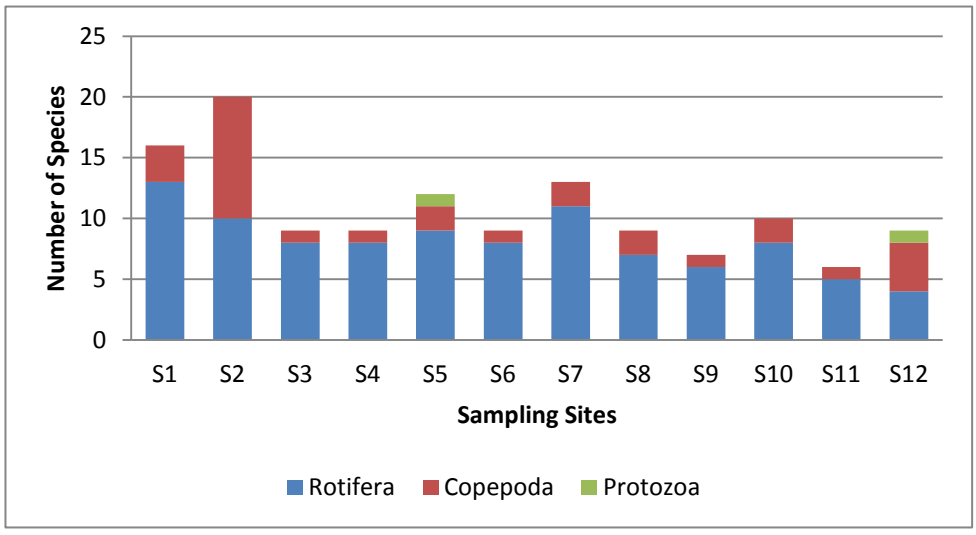


Fig 119: Density of Zooplankton during April 2012

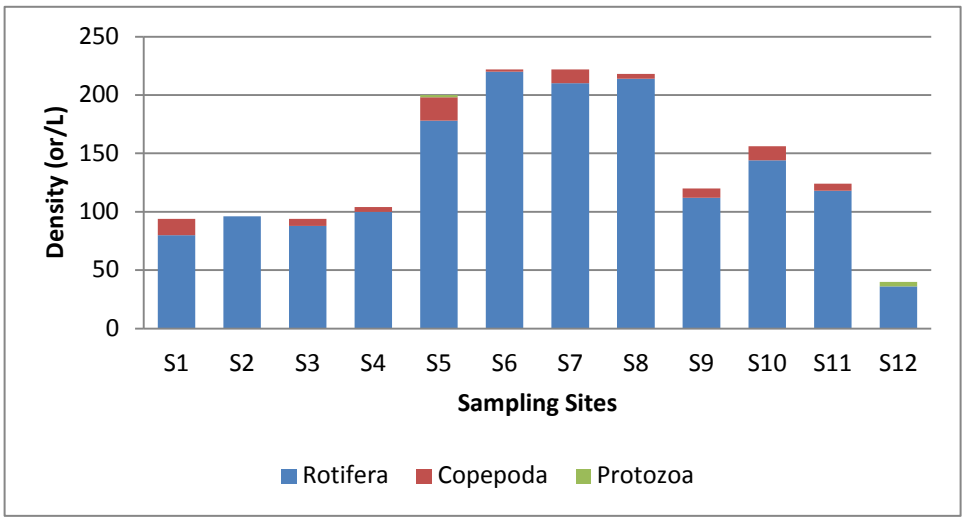


Fig 120: Diversity of Zooplankton during May 2012

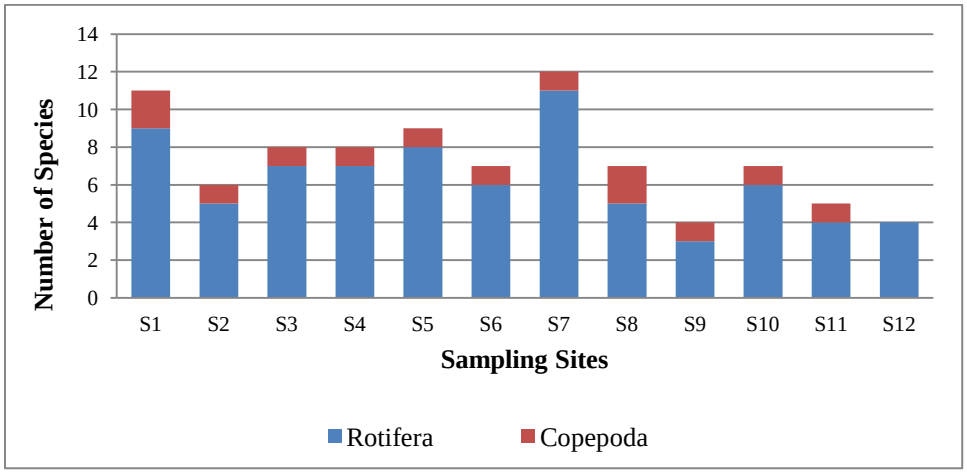


Fig 121: Density of Zooplankton during May 2012

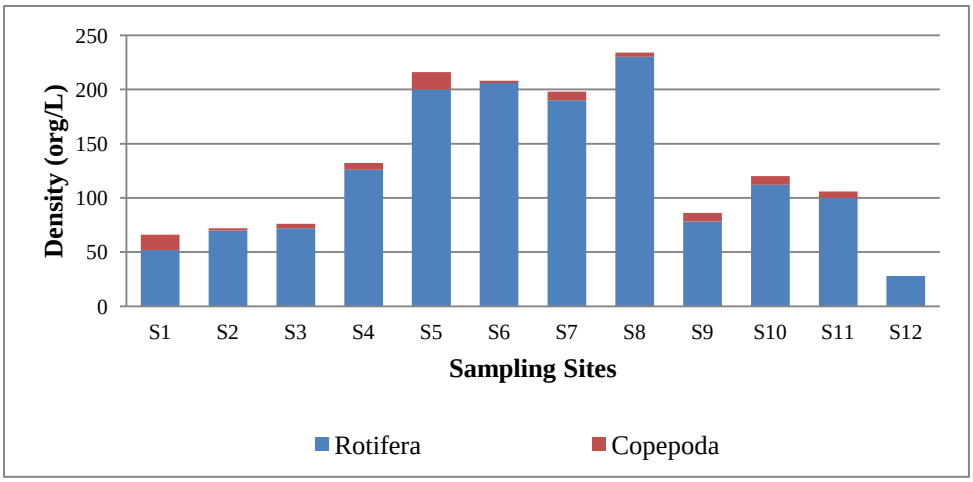


Fig 122: Diversity of Zooplankton during June 2012

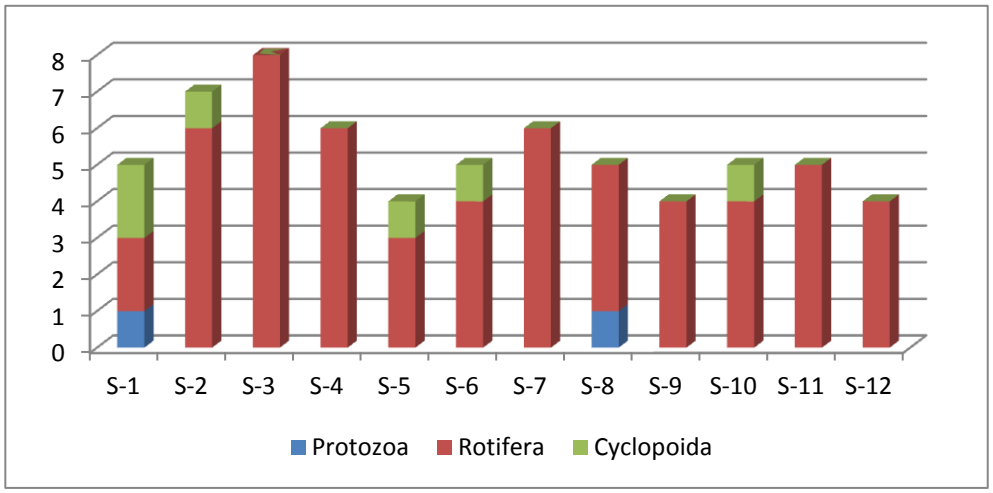


Fig 123: Density of Zooplankton during June 2012

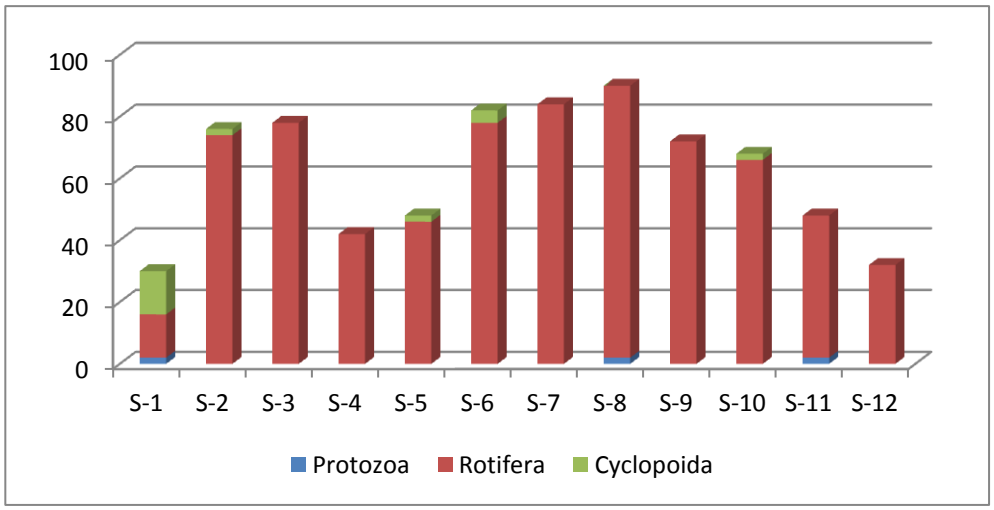


Fig 124: Diversity of zooplanktons during July 2012

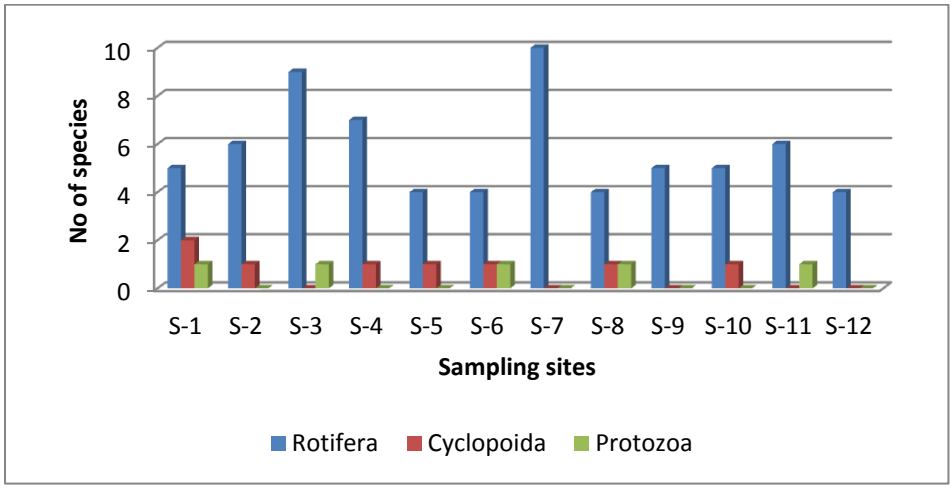


Fig 125: Density of zooplankton during July 2012

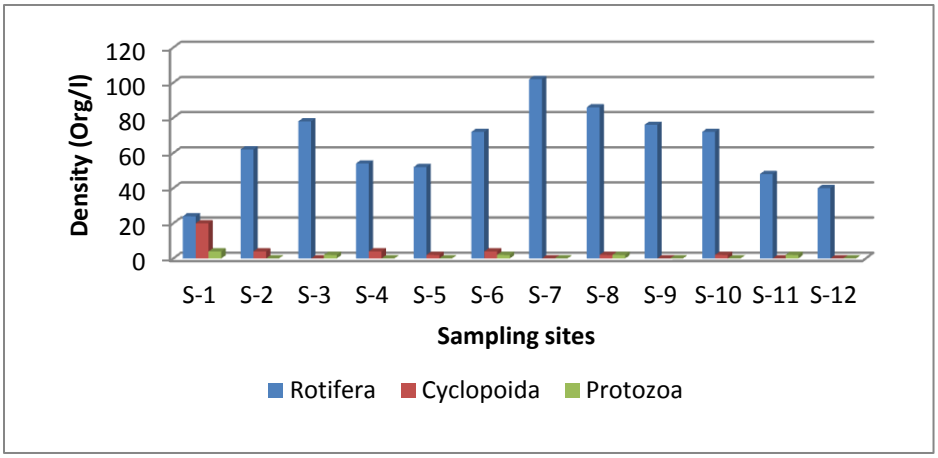


Fig 126: Diversity of zooplankton during September 2012

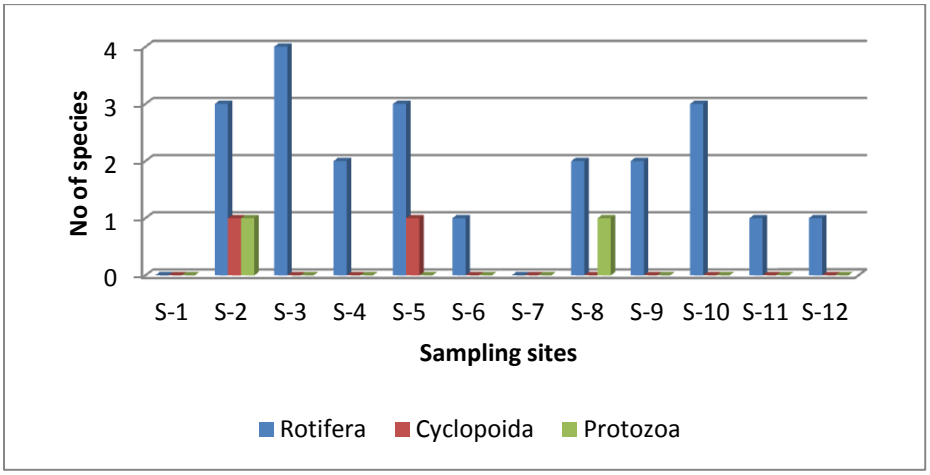


Fig 127: Density of zooplanktons during September 2012

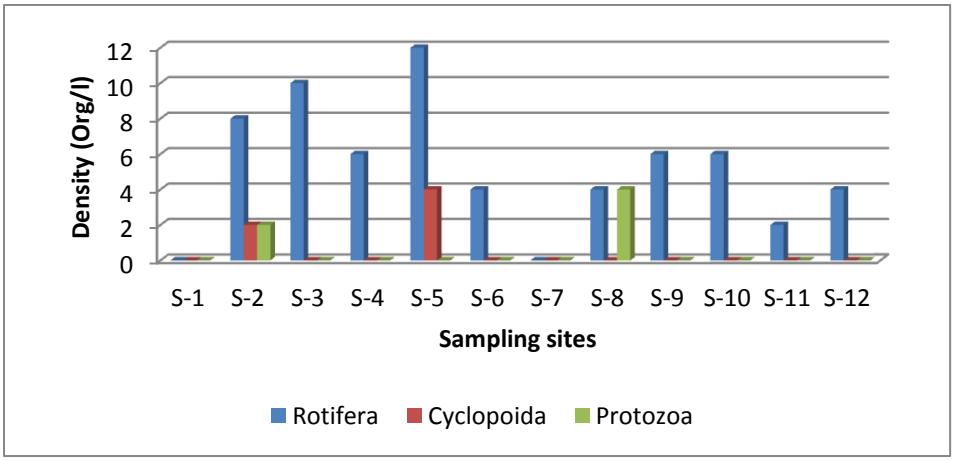


Fig 128: Diversity of zooplanktons during October 2012

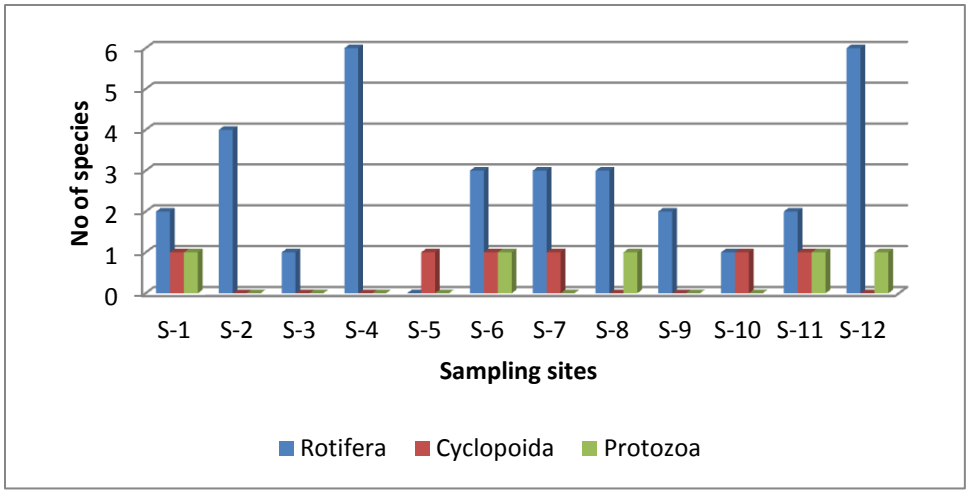


Fig 129: Density of zooplankton during October 2012

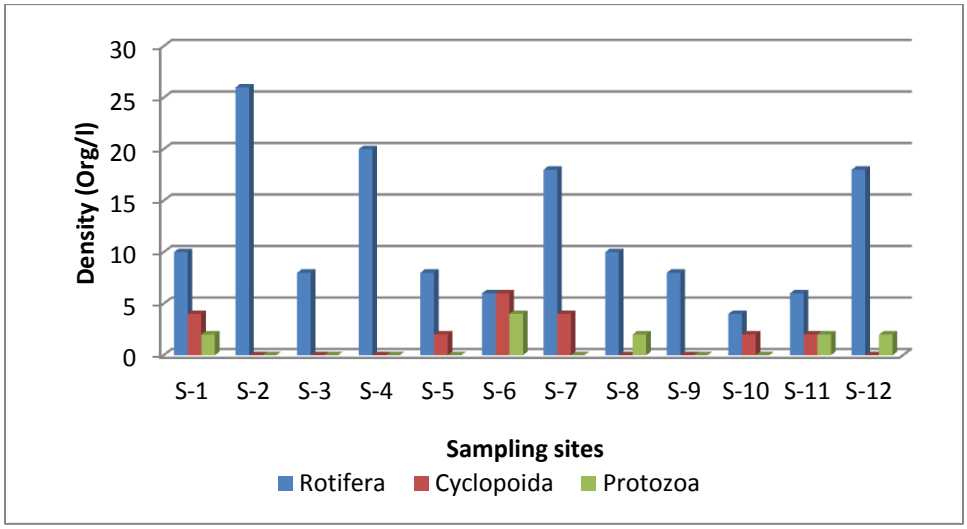


Table 15: Group wise species composition of Zooplankton community in Shahpura lake

S No	Species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
Group Rotifera													
1	*Anurae opsisfissa*	-	-	-	-	-	-	-	+	-	-	-	-
2	*Ascomorphella volvocicola*	+	+	+	+	+	+	+	+	+	+	+	+
3	*Asplanchna brightwellii*	-	-	-	-	-	-	-	+	-	-	-	-
4	*A. multiceps*	-	-	+	-	+	+	+	-	+	-	-	-
5	*Brachionus calyciflorus*	+	+	+	+	+	+	+	+	+	+	+	+
6	*B. angularis*	+	-	+	+	-	+	-	-	-	-	-	+
7	*B .bidentatusdentatus*	+	+	-	+	-	-	+	-	+	-	-	+
8	*B. budapestinensis*	+	+	+	-	-	+	+	+	+	-	-	+
9	*B.calycifloruspallas*	+	+	+	+	+	+	+	+	+	+	+	+
10	*B.calycifloruswithout spines*	-	-	-	-	-	+	-	-	-	-	-	-
11	*B.caudatus*	+	+	+	+	+	+	+	+	+	+	+	+
12	*B.diversicornis*	+	+	+	+	+	+	+	+	+	+	+	+
13	*B.durgaedhanapathi*	-	+	-	-	+	-	-	+	-	-	+	-
14	*B.falcatus*	-	-	+	+	-	-	-	-	-	-	-	-
15	*B.quadridentatus*	+	-	-	+	+	-	-	-	-	+	-	+
16	*B.rubens*	+	-	+	+	-	-	-	-	+	-	-	-
17	*Beauchampiella eudactylota*	-	-	-	-	-	+	-	-	-	-	-	-
18	*Epiphanes brachionus*	+	-	-	-	-	-	-	-	-	-	-	-
19	*Euchla nidiltata*	-	-	+	-	-	-	-	-	-	-	-	-
20	*Filinia opoliensis*	-	-	-	-	-	-	-	-	-	-	+	-
21	*F.pejleri*	+	-	-	+	-	+	-	+	-	-	-	+
22	*Horaella brehmi*	-	-	-	-	+	-	-	+	+	+	-	-
23	*Keratella cochlearis*	-	-	+	-	-	-	-	-	-	-	-	-
24	*Keratella tropica*	+	+	+	+	+	-	-	+	+	+	+	-
25	*Lecanebula sp.*	-	-	-	-	-	-	+	-	-	-	-	-
26	*L. horenmanni*	-	-	-	-	-	-	-	+	-	-	-	-
27	*L. luna*	-	-	-	-	-	-	-	+	-	-	-	-
28	*L. lunaris*	-	-	-	-	-	-	-	-	-	+	+	-
29	*L.quadridentata*	-	-	-	-	-	-	-	-	-	-	+	-
30	*Monomatta sp.*	+	-	-	-	+	-	+	+	-	-	-	-
31	*Mytilina biscucata*	-	-	-	-	-	+	-	-	-	-	-	-
32	*M. ventralis*	+	-	-	+	-	-	+	-	-	-	-	-
33	*Notomatta sp.*	-	-	-	+	-	-	-	+	-	-	-	-
34	*Plationus patulus*	+	+	-	-	-	-	-	-	-	-	-	-
35	*Polyarthra sp.*	-	-	-	-	-	-	-	+	-	-	-	-
36	*Pompholy xsulcata*	+	+	+	+	+	+	+	+	+	-	-	-
37	*Proales sp.*	-	-	-	-	+	-	-	-	-	-	-	-
38	*Synchae torstylats*	-	-	-	-	-	-	+	-	+	-	-	-

S No	Species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
39	*Taphrocampa sp.*	+	-	-	-	-	-	-	-	-	-	-	-
40	*Testudinella sp.*	-	-	-	-	-	-	-	+	+	-	-	-
41	*Testudinella patina*	-	-	+	+	+	+	-	+	+	-	+	+
42	*Trichocerca rattus*	+	-	-	+	+	+	+	+	-	+	+	-
43	*Tripleuchla nisplicata*	-	+	-	-	-	-	-	-	-	-	-	-
Group Copepoda													
44	*Calanoid copepod*	-	-	-	-	+	-	-	-	-	-	-	-
458	*Cyclopoid copepod*	-	+	-	-	+	-	-	+	+	-	+	-
46	*Diaptomus*	+	-	-	-	+	-	-	-	+	-	-	-
Group Cyclopoida													
47	*Cyclops sp.*	+	+	+	+	+	+	+	+	+	+	+	+
48	*Nauplius larvae*	+	-	-	-	+	+	-	+	+	+	-	-
49	*Nauplius stages*	-	-	-	-	-	-	-	+	-	-	-	-
Group Cladocera													
50	*Alonella excisa*	-	-	-	-	-	-	-	-	-	+	-	-
51	*Ceriodaphnia dubia*	-	+	-	-	-	-	-	-	-	-	-	-
52	*Daphnia longiremis*	-	+	-	-	-	-	+	-	-	-	-	-
53	*Moinamicrura*	-	-	-	-	-	-	-	-	-	-	+	-
54	*Scapholebris mucronata*	-	+	-	-	-	+	-	-	-	-	-	-
Group Ostracoda													
55	*Cypris sp.*	-	-	-	-	-	-	-	-	-	-	-	+
Group Protozoa													
56	*Centropyxcis sp.*	-	-	-	-	-	-	-	+	+	-	-	-
57	*Childonella sp.*	-	-	-	-	-	-	-	-	-	-	-	+
58	*Difflugia sp.*	-	-	-	-	-	-	-	+	-	-	+	-
59	*Euglypha sp.*	+	-	-	-	-	-	+	-	-	-	+	-
60	*Paramecium sp.*	-	-	-	-	+	-	-	-	-	-	-	-
61	*Vorticella sp.*	-	-	-	-	-	-	-	-	-	-	-	+

c. Benthos:

A total 43 species were recorded from Shahpura lake during the entire study period belonging to three phylums namely Arthropoda, Mollusca and Annelida. Arthropoda was most dominant phylum with 25 species followed by Mollusca with 13 species and Annelida with 5 species. The dominance species of Arthropoda namely *Chironomus, Ablabesmyia, Hydropsyche, Limnephilus, Proclalius, Amphiagrion, Culicidae pupa, Hesperocorixa, Notonecta.* Five species of Annelida namely *Branchiura, Lumbricullus, Glossiphornia complanata, Glossiphornia leteroculata, Helobdella stagnalis* and the most dominant benthic species of Mollusca (group Gastropoda) namely *Bellamya bengalensis, B. crassa, B. crassispiralis, B. dissimilis, Indoplanorbis exustus, Physa sp, Thira tuberculata.* The phylum Arthropoda contribution of benthic diversity an over all of 58%, followed by Annelida 12% and Mollusca. A total benthic density varied between 178 to 4800 ind. / m^2 in Shahpura Lake. The maximum density of benthos 4800 ind./m^2 at site 12 in the month of January and minimum density of 178 ind./m^2 was recorded at site 1 and site 9 in the month of July and September.

Phylum Arthropoda:

A total benthos diversity of 25 species of phylum Arthropoda were recorded in Shahpura lake during the study period. Phylum Arthropoda showed maximum benthos diversity of 19 species at site 12 and minimum diversity 3 species at site 1, site 2, site 4, site 10 and site 11 during the study period. The density of Arthropoda were recorded between 44 to 3111 ind./m^2 during the study period. The maximum benthos density of 3111 ind./m^2 was recorded at site 12 in the month of January and minimum density 44 ind./m^2 recorded at site 3 site 4, site 6, site 7 and site 11 in the months of November, April, June, July and September.

Phylum Mollusca:

A total benthos diversity of 13 species of phylum Mollusca were recorded in Shahpura lake during the study period. Phylum Mollusca showed maximum benthos diversity of 10 species at site 9 and minimum diversity 2 species at site 11 during the study period. The density of Mollusca were recorded between 44 to 2711 ind./m^2 during the study period. The maximum benthos density of 2711 ind./m^2 was recorded at site 12 in the month of January and minimum density 44 ind./m^2 recorded at site 4, site 5, site 9, site 10 and site 11 in the months of November, February and May.

Phylum Annelida:

A total benthos diversity of 5 species of phylum Annelida were recorded in Shahpura lake during the study period. Phylum Annelida showed maximum benthos diversity of 4 species at site 12 and minimum diversity 1 species at site 8 during the study period. The density of Annelida were recorded between 44 to 2267 ind./m^2 during the study period. The maximum

benthos density of 2267 ind./m^2 was recorded at site 9 in the month of January and minimum density 44 ind./m^2 recorded at site 9 month of November.

Fig 130: Percentage composition of benthos in Shahpura lake

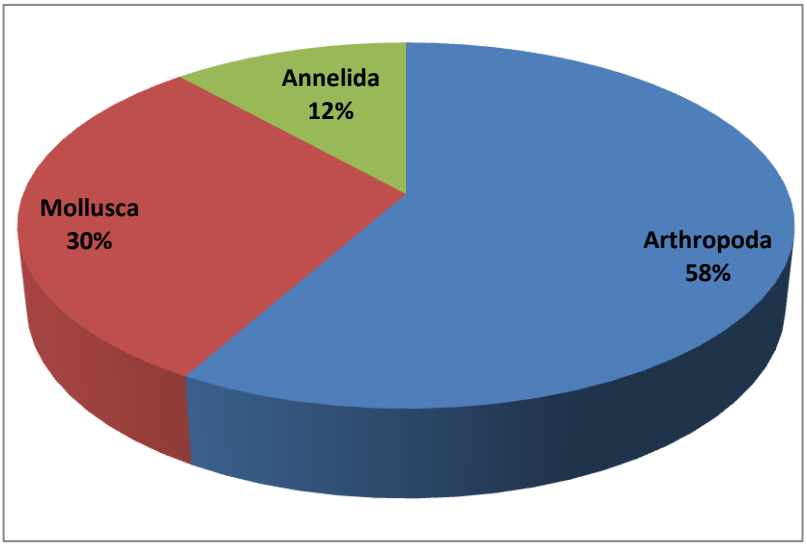


Fig 131: Diversity of Benthos during November 2011

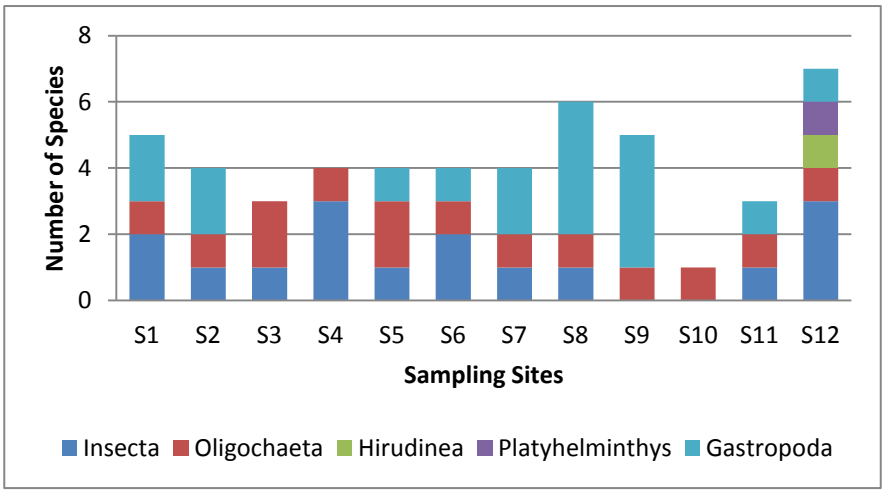


Fig 132: Density of Benthos during November 2011

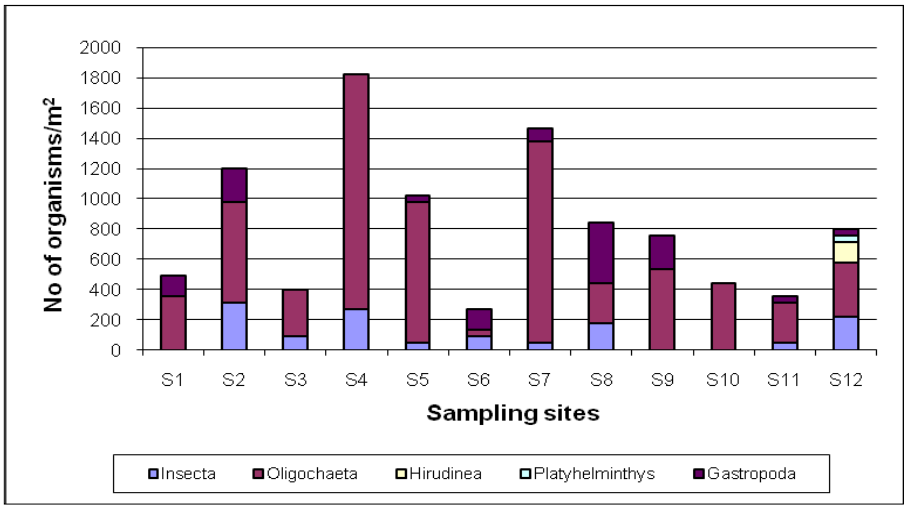


Fig 133: Diversity of Benthos during December 2011

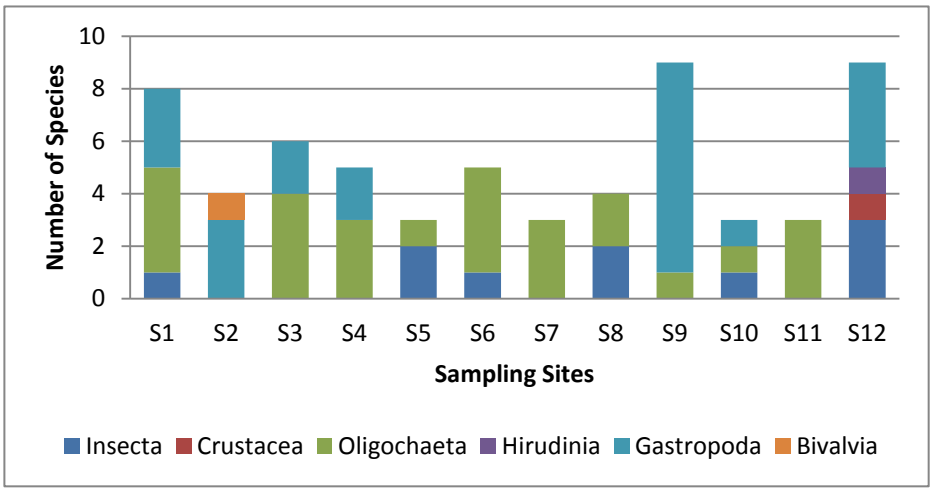


Fig 134: Density of Benthos during December 2011

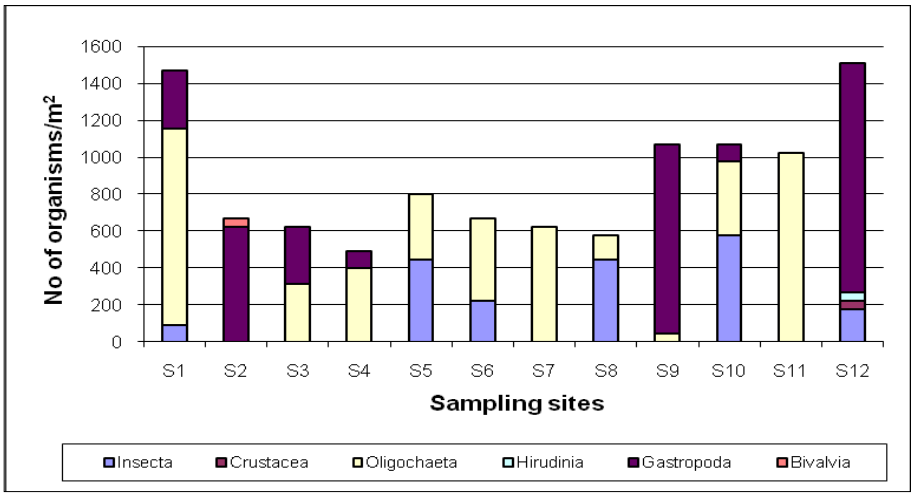


Fig 135: Diversity of Benthos during January 2012

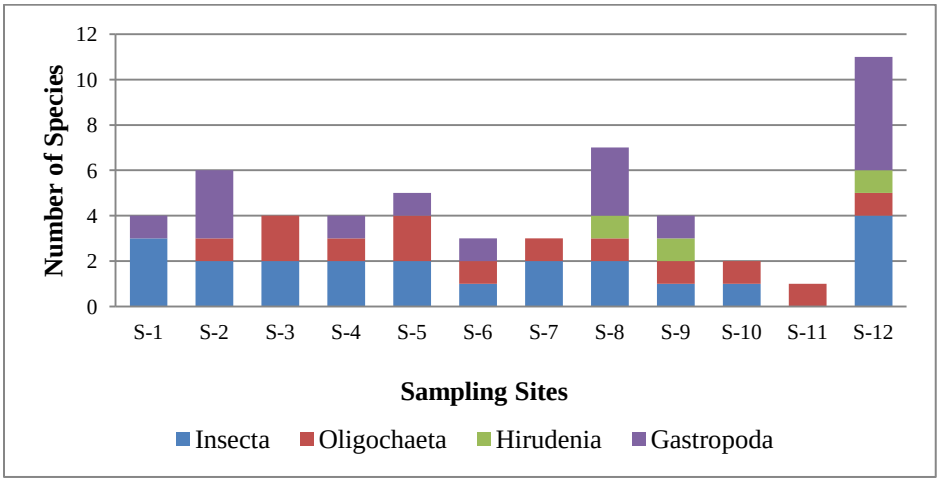


Fig 136: Density of Benthos during January 2012

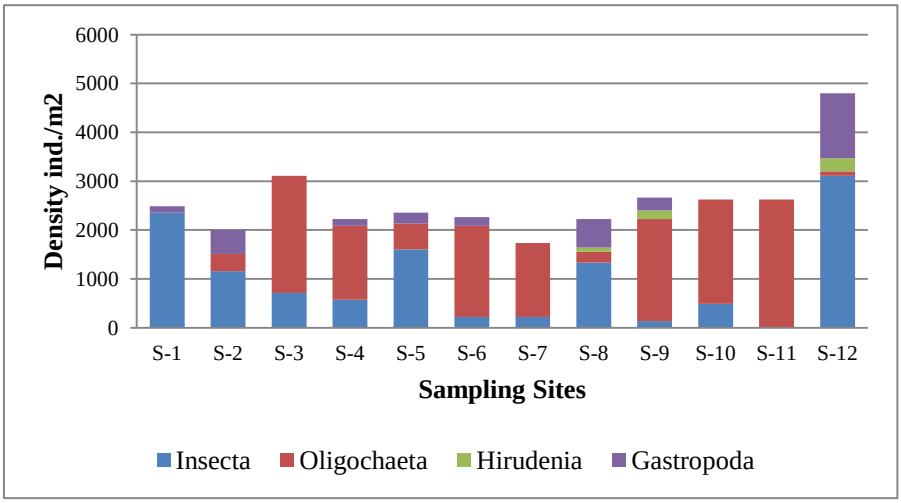


Fig 137: Diversity of Benthos during February 2012

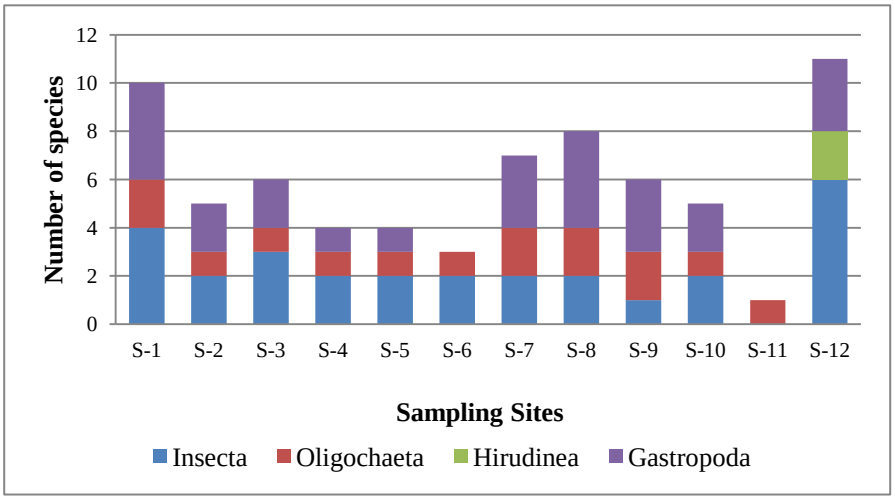


Fig 138: Density of Benthos during February 2012

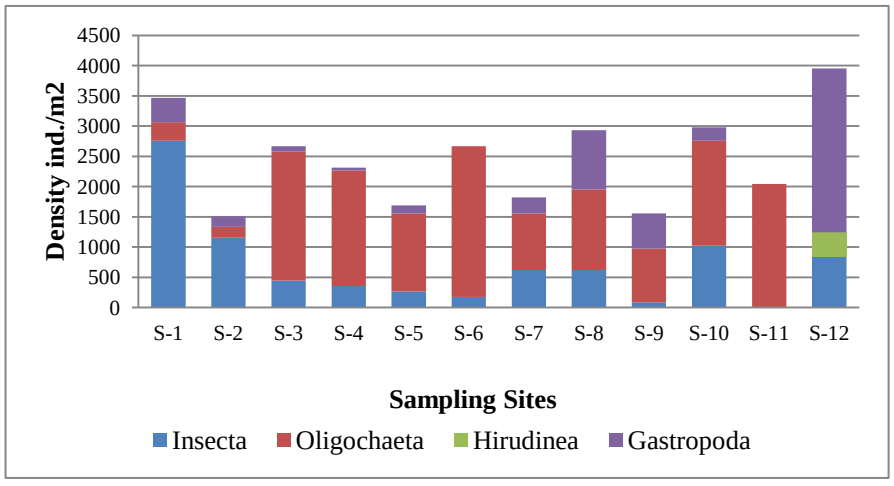


Fig 139: Diversity of Benthos during March 2012

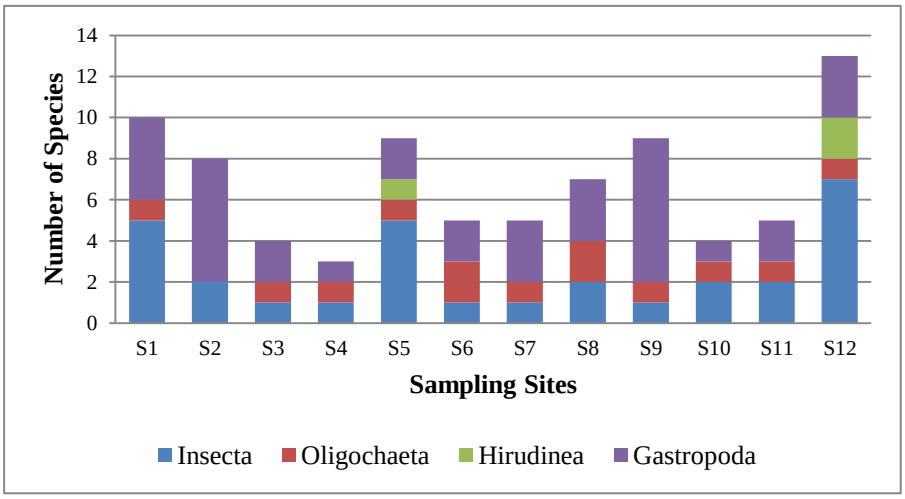


Fig 140: Density of Benthos during March 2012

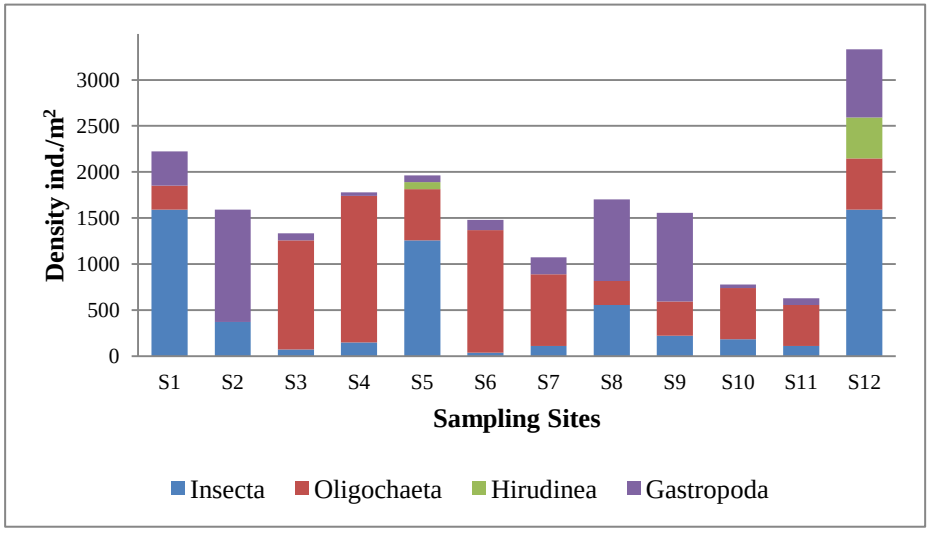


Fig 141: Diversity of Benthos during May 2012

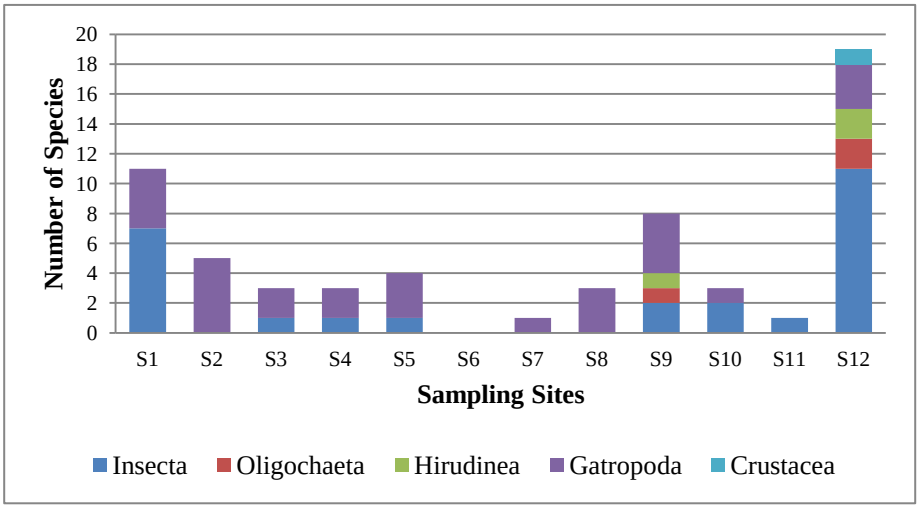


Fig 142: Density of Benthos during May 2012

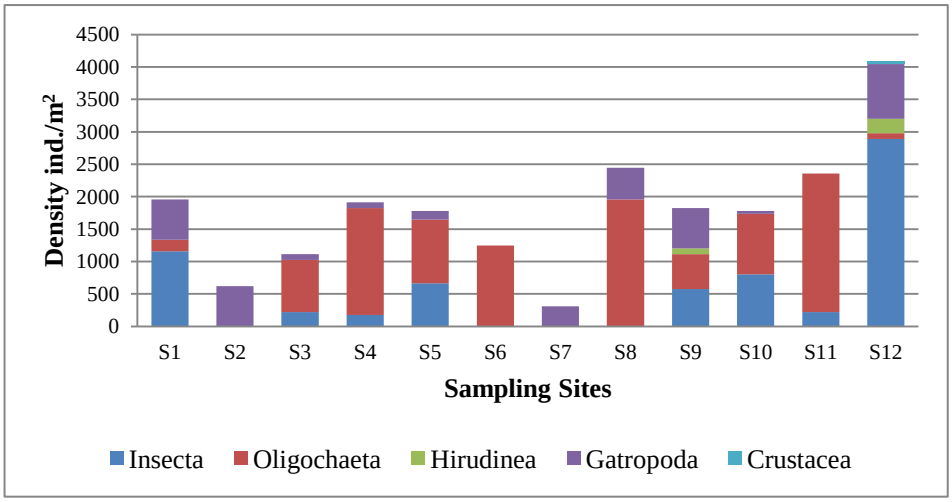


Fig 143: Diversity of benthos in the month of June 2012

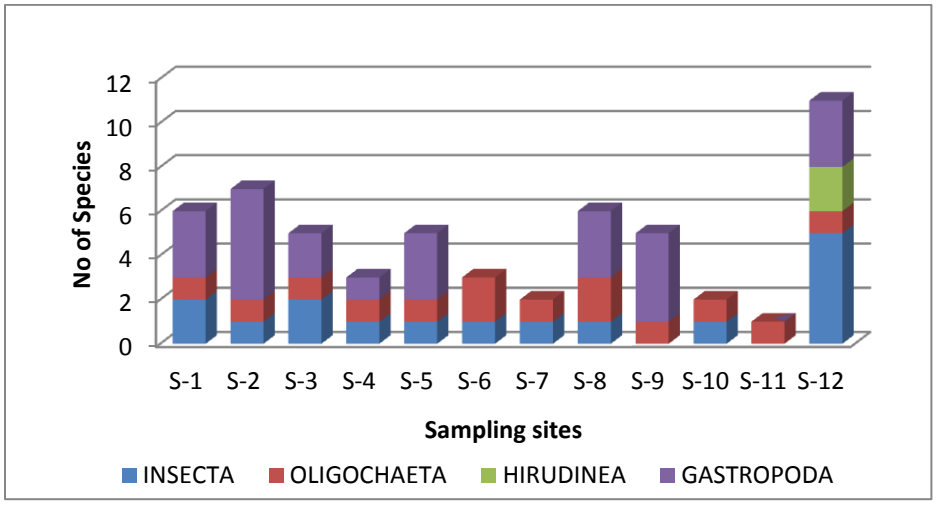


Fig 144: Density of benthos in the month of June 2012

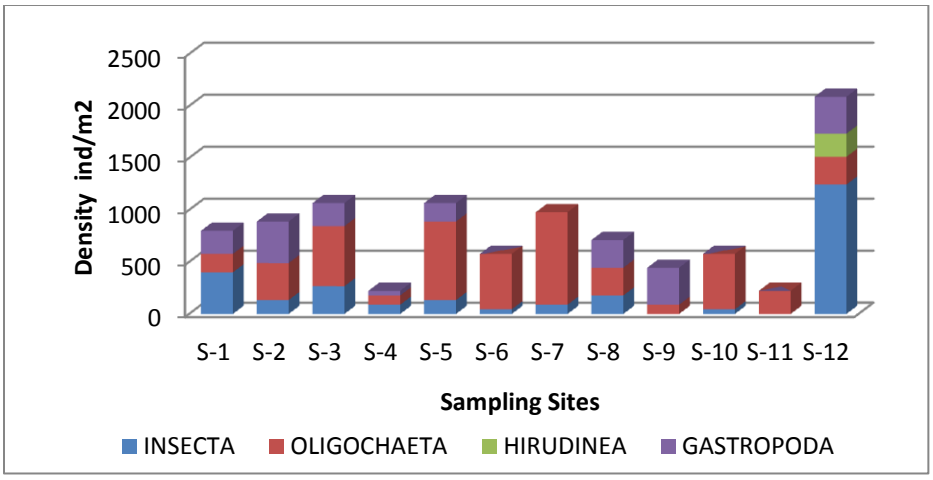


Fig 145: Diversity of benthos in the month of July 2-12

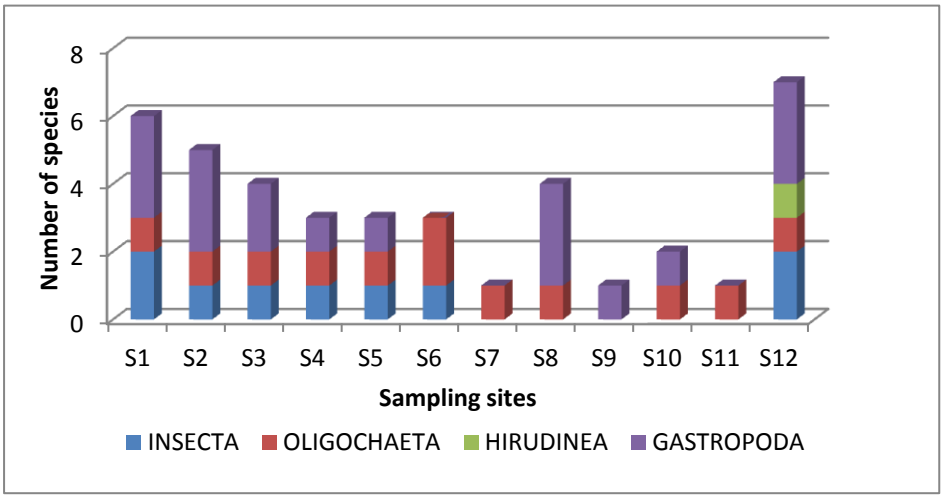


Fig 146: Density of benthos in the month of July 2012

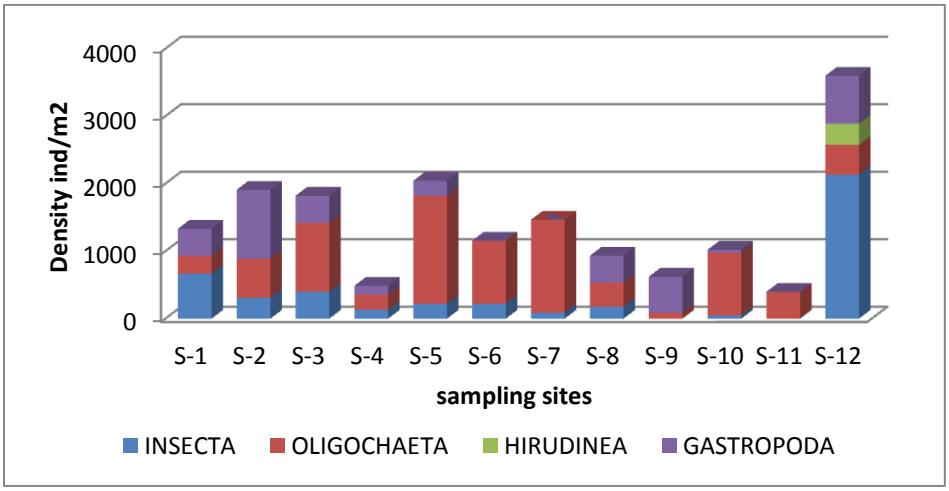


Fig 147: Diversity of Benthos during September 2012

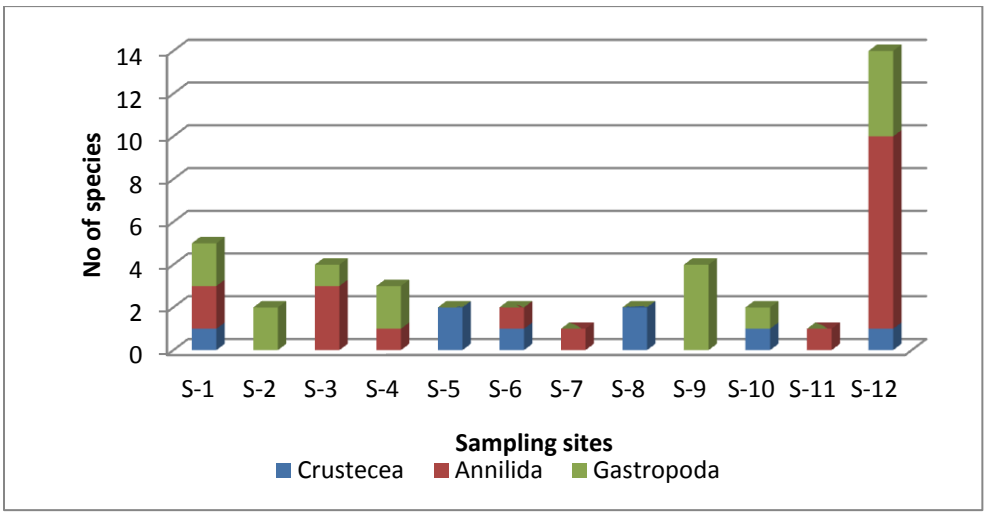


Fig 148: Density of benthos in September 2012

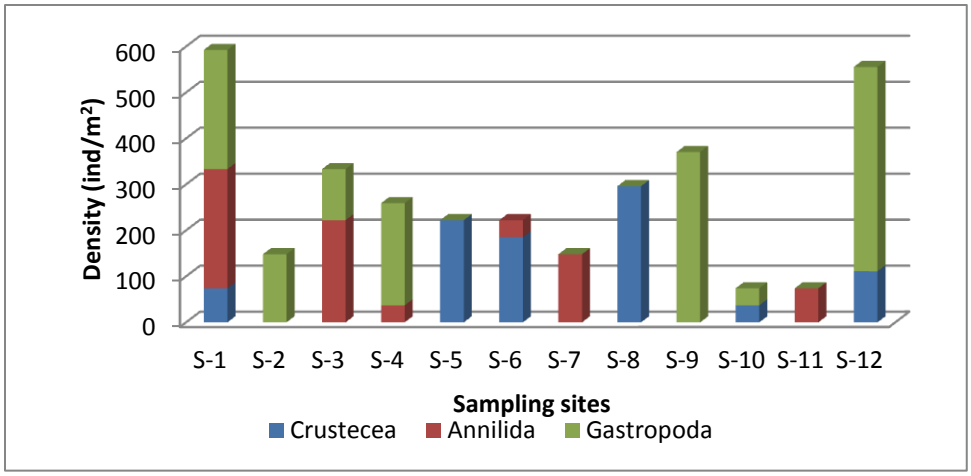


Fig 149: Diversity of Benthos during October 2012

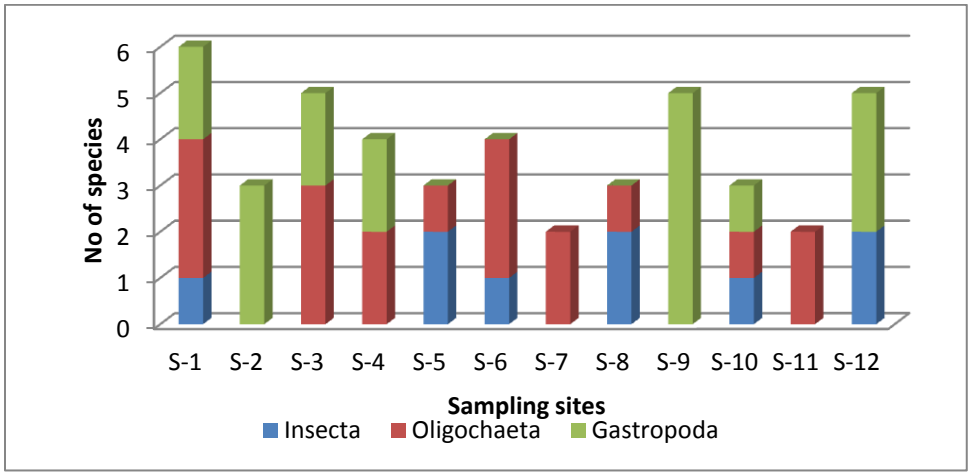
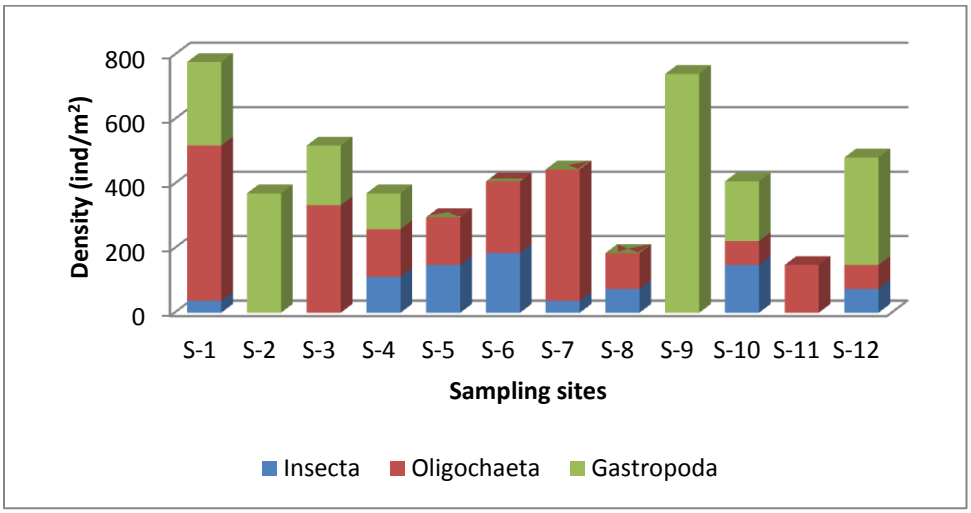


Fig 150: Density of benthos during October 2012



Tab 16: List of benthos in Shahpura lake during November 2011 to October 2012.

S No	Species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
INSECTA													
1	*Amphiagrion sp.*	+	-	-	-	-	-	-	-	-	-	-	+
2	*Plea sp.*	-	-	-	-	-	-	-	-	-	-	-	+
3	*Libellula sp.*	+	-	-	-	-	-	-	-	-	-	-	+
4	*Limnephilus sp*	-	-	-	-	-	-	-	-	-	-	-	+
5	*Haliplus futuvs*	-	-	-	-	-	-	-	-	-	-	-	+
6	*Hydroporus sp.*	-	-	-	-	-	-	-	-	-	-	-	+
7	*Ishnura ramburi*	+	-	-	-	-	-	-	-	-	-	-	-
8	*Pachidiplax longipennis*	-	-	-	-	-	-	-	-	-	-	-	+
9	*Proclalius sp.*	+	-	+	-	-	-	+	+	-	-	-	-
10	*Hesperocorixa sp.*	+	-	-	-	+	-	-	-	-	-	-	+
11	*Tabanidae sp.*	-	-	-	-	-	-	-	-	-	-	-	+
12	*Notonecta sp.*	+	-	-	-	+	-	-	-	-	-	-	+
13	*Tipula sp.*	+	-	-	-	-	-	-	-	-	-	-	+
14	*Platambus maculatus*	-	-	-	-	-	-	-	-	-	-	-	+
15	*Ranatra sp.*	+	-	-	-	-	-	-	-	-	-	-	-
16	*Rhaphidolabis sp.*	-	-	-	-	-	-	-	-	-	-	-	+
17	*Rhagovelia sp.*	-	-	-	-	-	-	-	-	-	-	-	+
18	*Psephenidae sp.*	-	-	-	-	-	-	-	-	-	-	-	+
19	*Culicidae pupa*	+	-	-	-	-	+	-	-	-	-	-	-
20	*Chironomus tentans*	+	+	+	+	+	+	+	+	+	+	+	+
21	*Ablabesmiya sp.*	+	+	+	+	+	+	+	+	+	+	+	+
22	*Limnephilidae larva*	-	-	-	-	-	-	-	-	-	-	-	+
23	*Chaoborus sp.*	-	-	-	-	+	-	-	-	-	-	-	-
CRUSTACEA													
24	*Garranarus pulex*	-	-	-	-	-	-	-	-	-	-	-	+
OLIGOCHAETA													
25	*Lumbriculus* sp.	+	+	+	+	+	+	+	+	+	+	+	+
26	*Branchiura sp.*	+	-	+	-	+	+	+	+	+	-	-	-
HIRUDINEA													
27	*Glossiphornia complanata*	-	-	-	-	-	-	-	+	+	-	-	+
28	*Glossiphornia leteroculata*	-	-	-	-	-	-	-	-	+	-	-	-
29	*Glossiphonia* sp.	-	-	-	-	-	-	-	-	-	-	-	+
PLATYHELMINTHES													
30	*Dugesia tigrina*	-	-	-	-	-	-	-	-	-	-	-	+
GASTROPODA													
31	*Lymnaea luteola*	+	-	-	-	-	-	-	-	+	-	-	-

S No	Species	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
32	*Bellamya bengalensis*	+	+	+	+	+	+	+	+	+	+	+	+
33	*Bellamya crassispiralis*	+	+	-	-	+	-	-	-	+	-	-	+
34	*Bellamya crassa*	+	+	+	-	+	-	+	+	+	-	+	+
35	*Bellamya dissimilis*	-	-	-	-	-	+	+	-	+	-	-	-
36	*Physa* sp.	+	+	-	-	+	-	+	-	-	-	-	+
37	*Thiara tuberculata*	-	+	+	+	+	+	+	+	+	-	-	+
38	*Thira riqueti*	-	-	-	-	-	-	-	-	-	-	-	+
39	*Thira pyamis*	-	-	-	-	-	-	+	-	+	-	-	-
40	*Hydrobioides nassa*	-	-	-	-	-	-	-	+	+	+	-	-
41	*Indoplanorbis exustas*	+	+	-	+	-	-	+	+	+	+	-	+
42	*Brotia lineata*	-	+	-	-	-	-	-	-	-	-	-	-
43	*Botia costula*	-	-	-	+	-	-	-	-	+	-	-	-

d. **Macrophytes:**

The term "aquatic macrophyte" refers to macroscopic vegetation, including macroalgae, mosses, ferns and angiosperms that grow in aquatic and wetland habitats. The macrophytes are sensitive indicators of water quality and conditions of their habitats. They are affected by a wide variety of environmental factors including geology, landforms and pollution. The aquatic macrophytes play an important role in the production process, nutrient dynamics and oxygen budget of water bodies.

The macrophytes of Shahpura lake were collected from different sites and classified according to their biological types, habitat and botanical classification (Table…….). The present investigation of Shahpura lake, total 11 species of macrophytes were reported during November 2011 to October 2012. There were 2 species of submerged *Najas minor, Hydrilla verticillata,* 2 species of free floating *Pistia stratiotes, Eichhornia crassipes* and 7 emergent species namely *Polygonum glabrum, Cyperus articulatus, Sagittaria sagittifolia, Begrgia cappensis, Nymphaea nouchali,Phragmites carka, Typha sp* were recorded. *Typha sp.* was most dominating species at site 2 and site 4 similarly *Eichhornia crassipes* were second most dominating species at site 8 and site 12 and *Hydrilla verticillata* was recorded at Site-12 down stream of lake .

The *Phragmites* sp. and *Typha* sp. are good examples of emergent species used in constructed wetland treatment systems. These emergent plants play a vital role in the removal and retention of nutrients in a natural or constructed wetland. Although emergent macrophytes are less efficient at lowering Nitrogen and Phosphorus contents by direct uptake due to their lower growth rates (compared to floating and submerged plants), their ability to uptake Nitrogen and Phosphorus from sediment sources through rhizomes is higher than from the water.

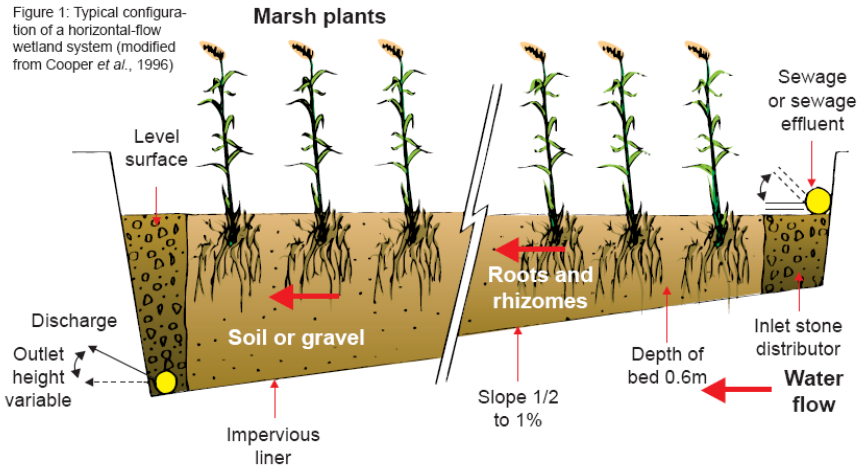


Figure 1: Typical configuration of a horizontal-flow wetland system (modified from Cooper *et al.*, 1996)

Surface Flow (SF) - The use of SF systems is extensive in North America. These systems are used mainly for municipal wastewater treatment with large wastewater flows for nutrient polishing. The SF system tends to be rather large in size with only a few smaller systems in use.

Reference: Wetlands International - Malaysia Office (2003): The use of constructed wetlands for wastewater treatment

Floating and submerged plants are used in an aquatic plant treatment system. A range of aquatic plants have shown their ability to assist in the breakdown of wastewater. The Water Hyacinth (*Eichhornia crassipes*), and Duckweed (*Lemna*) are common floating aquatic plants which have shown their ability to reduce concentrations of BOD, TSS and Total Phosphorus and Total Nitrogen. However prolonged presence of *Eichhornia crassipes* and *Lemna* can lead to deterioration of the water quality unless these plants are manually removed on a regular basis. These floating plants will produce a massive mat that will obstruct light penetration to the lower layer of the water column that will affect the survival of living water organisms. This system is colonised rapidly with one or only a few initial individuals. The system needs to be closely monitored to prevent attack from these nuisance species. Loss of plant cover will impair the treatment effectiveness. Maintenance cost of a floating plant system is high. Plant biomass should be regularly harvested to ensure significant nutrient removal. Plant growth also needs to be maintained at an optimum rate to maintain treatment efficiency.

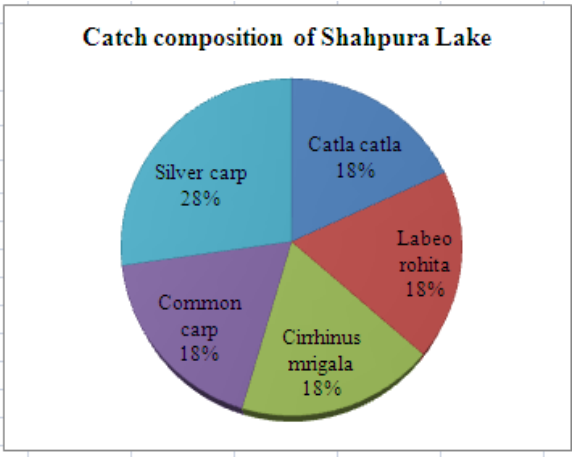
Table 17 : List of Macrophytes in Shahpura Lake

S No	Species	Site Location
1	*Najas minor*	S-8
2	*Hydrilla verticillata*	S-12
3	*Polygonum glabrum*	S-1, S-2, S-4, S-8 , S-9 and S-12
4	*Cyperus articulates*	S-9
5	*Sagittaria sagittifolia*	S-2, S-4, S-9 and S-12
6	*Pistia stratiotes*	S-8
7	*Eichhornia crassipes*	S-1, S-5 and S-8
8	*Begrgia cappensis*	S-1, S-8, S-12
9	*Nymphaea nouchali*	S-1
10	*Phragmites carka*	S-2,
11	*Typha*	S-2, S-4

e. Fish Fauna:

In our two months study we observed 5 culturable species of fishes i.e., *Catla catla, Labeo rohita*, *Cirrhinus mrigala*, silver carp, Common carp, and *Tilapia mossambica* which is banned for culture. Silver carp, Common carp and Tilapia are exotic species. The first two are grown in fish pond but Tilapia is considered to be harmful for natural pond ecosystem and house in banned for culture in India.

The study is continuous and carried out in our further observation. In present condition we were unable to collect the fish samples for diversity study due to non cooperation of fishermen groups. The present catch statistics of fish in Shahpura Lake was 110 kg/day given below as per the statement given by fishermen group head Mr Raju Batham. Actual condition showed that the production of tilapia is more than the culturable species. But due to ban of Fisheries Department for culture of tilapia the actual production of tilapia was not recorded.



During the study of Shahpura lake observed that the density of Tilapia is very high. According to Fishermen group head Tilapia having large size in Shahpura lake which was more then half kg. During the local observation and market survey this size of tilapia was not found in any other place of Madhya Pradesh.

5. Assessed of trophic status of lake using different index

5.1 Carlson Trophic State Index

The Trophic state index (TSI) of Carlson was determined. The TSI values calculated on the basis of Secchi Disk (SD), Chlorophyll-a (chl-a) and Total phosphorous (TP). During the study period the Carlson's TSI were recorded in Shahpura Lake is between 77.89 to 84.91. The highest TSI value was recorded in the month of May (84.91) at site-10 and the lowest value was recorded in the month of Feb (77.89) at site-4.

The **TSI (chl-a**) was found in Shahpura Lake is between 37.06 to 59.10 µg/l. during the study period the highest TSI (chl-a) value was recorded in the month of May (59.10 µg/l) at site-10 and the lowest value was recorded in the month of Feb (37.06 µg/l) at site-4

The **TSI (SD)** was recorded in Shahpura Lake is between 70.57 to 78.85 meters. The highest TSI (SD) value was recorded in the month of Jan (78.85m) at site-11 and the lowest value was recorded in the month of Feb and March (70.57m) at site- 4. Site-11 and site-3.

The **TSI (TP)** was recorded in Shahpura Lake is between 115.85 to 127.64 µg/l. the highest TSI (TP) value was recorded in the month of Feb (127.65 µg/l) at site-1 and the lowest value was recorded in the month of July (11.85 µg/l) at site-10.

Table: List of the Carlson Trophic State Index in Shahpura Lake.

SITES	Maximum -TSI	Jan	Feb	March	April	May	June	July	Sept	Oct
S-1	70 – 100+	82.51	81.71	83.20	82.98	83.68	80.86	82.39	80.29	81.63
S-2		81.74	82.46	81.38	81.62	82.01	81.38	82.04	80.92	81.71
S-3		82.17	80.72	82.18	80.62	82.04	80.77	81.66	80.75	81.22
S-4		80.68	77.89	81.05	80.72	81.41	82.53	82.57	80.21	80.55
S-5		81.31	80.60	81.02	82.97	83.15	82.18	82.80	79.39	80.49
S-6		80.99	79.34	80.54	83.68	83.73	82.12	83.02	80.73	82.57
S-7		81.38	79.06	81.30	80.72	82.23	80.56	81.68	79.81	81.12
S-8		82.01	80.02	82.27	83.14	83.32	82.02	82.96	81.02	82.49
S-9		82.25	80.62	81.92	83.99	84.65	81.23	83.16	80.92	82.20
S-10		82.59	80.50	81.83	84.36	84.91	80.75	83.10	80.62	81.92
S-11		82.24	81.53	80.82	80.87	84.43	80.37	82.59	80.95	81.48
S-12		83.13	83.91	81.65	81.74	84.03	84.24	84.40	78.07	84.32

5.2 Trophic status of Shahpura Lake by Nygard index:

Nygard's indices – the Myxophycean Chlorophycean, Diatoms, Euglenoids & Compound were used for evolution of Eutrophication. In present investigation all the stations of lakes showed Eutrophic except index of diatoms of lakes.

In present study we define trophic status of Lake from Nygard Indices. In present study of Shahpura lake Nygard indices shows **Mixophycean** value of Shahpura Lake varied between 0.03 203.00. The highest value in the month of June (203.00) at site-1 and lowest value was recorded in the month of Jan (0.03) at site-5. The Chlorophycean value of Shahpura Lake varied between 0.83 to 66.00. The **Chlorophycean** shows highest value in the month of Feb (66.00) at site-3 and lowest value show in the month of July (0.83) at site-12.the **Diatoms** value ranged between 0.01 to 2.50. The highest value of **Diatoms** show in the month of May (2.50) at site-10 and lowest value show in the month of Jan (0.01) at site-2**.** The **Euglenophycean** value ranged between 0.03 to 202.05.The **Euglenophycean** highest value shows in the month of May (202.05) at site-5 and lowest value show in the month of March (0.03) at site—12, and the Compound value ranged between 16.5 to 528.67. The **Compound** highest value show in the month of June (528.67) at site-5 and lowest value show in the month of Jan (16.5) at site-10 (Fig 151). All index value comes under eutrophic status.

Fig 151: Monthly Compound Nygard index values of Shahpura lake

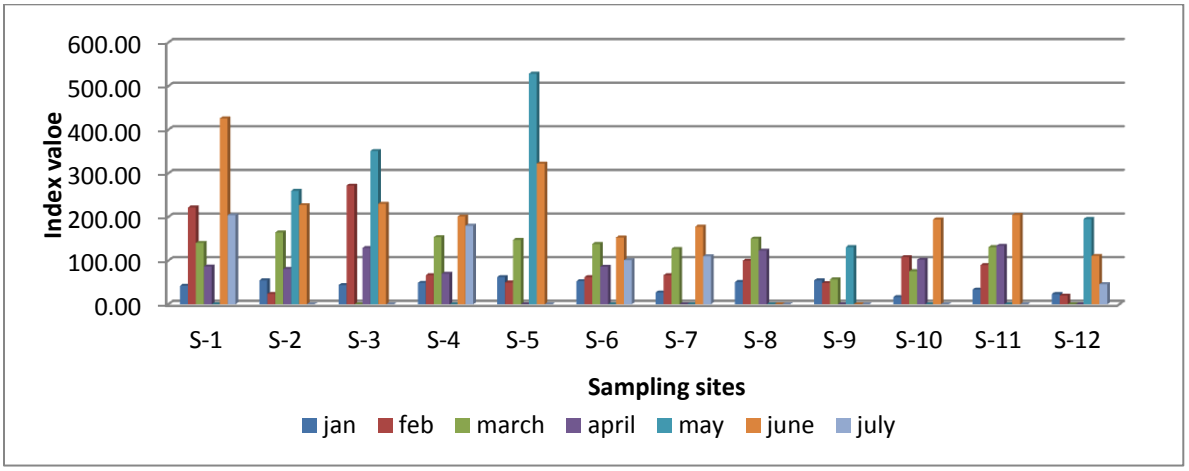


Table 18: Nygards algal index for estimation algal trophic status of lake due to presence of high Nutrients in Shahpura lake.

Index	Index range	Jan	Feb	March	April	May	June	July
Mixophyceae	**0.0 – 0.4**	0.42	21.36	0.66	5.66	26.15	36.58	20.92
Chlorophycean	**0.0 – 0.7**	0.99	24.69	13.30	13.08	20.13	12.15	2.90
Diatom	**0.0 – 0.3**	0.00	0.00	0.03	0.02	0.29	0.18	0.00
Euglenophycean	**0.0 – 0.2**	4.16	43.40	0.30	0.49	214.49	0.20	0.00
Compound	**0.0 – 0.1**	**42.71**	**94.11**	**107.20**	**67.63**	**402.31**	**187.39**	**53.42**

5.3 Biomonitoring indices using macrozoobenthos:

Benthic macroinvertebrate will be used to evaluate the water quality of Shahpura lake. The aquatic macroinvertebrates present in Shahpura lake were identified. Every group of invertebrate have different sensitivity towards the pollution. In BMWP scoring they will give certain score according to their sensitivity to pollution and finally the status of the water body will be classified as Clean, Slightly polluted, Moderately polluted, Heavily polluted and Severely polluted. In Shahpura lake highest BMWP scoring was reported as 64% heavily polluted and 28% severely polluted.

Table 19: Biological monitoring working party (BMWP) scoring for estimation of Lake water quality characteristics

Months	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
Nov-11	**4.2**	**3.8**	**1.3**	**4.5**	**2.5**	**3.5**	**3.0**	**4.0**	**4.4**	**3.0**	**4.0**	**3.4**
Dec-11	**1.9**	**5.3**	**2.7**	**2.4**	**2.0**	**1.2**	**1.0**	**1.8**	**4.8**	**3.0**	**1.0**	**4.9**
Jan-12	**3.5**	**3.3**	**1.5**	**2.0**	**2.4**	**3.0**	**2.0**	**3.9**	**3.0**	**1.5**	**1.0**	**5.5**
Feb-12	**2.7**	**3.4**	**3.67**	**2.75**	**2.75**	**1.67**	**3**	**3.375**	**3**	**3.2**	**5.36**	**5.45**
Mar-12	**4.4**	**4.25**	**4**	**2**	**3.375**	**3.2**	**4.2**	**3.43**	**4.33**	**2**	**3.4**	**3.46**
Apr-12	**2.8**	**4**	**6.4**	**3**	**3.25**	**3.4**	**4.4**	**3.43**	**4.71**	**2**	**3.67**	**3.54**
May-12	**4.45**	**5.4**	**3.75**	**5.25**	**4.2**	**1**	**6**	**3.4**	**3.71**	**2**	**1.5**	**4.11**
Jun-12	**3.33**	**3.58**	**3.4**	**3**	**3.6**	**1.33**	**1.5**	**3.17**	**4.4**	**1.5**	**1**	**3.45**
Jul-12	**4.25**	**3.6**	**3.75**	**3**	**2**	**1.33**	**1**	**4**	**3**	**3.5**	**1**	**3.28**
Sep-12	**3.6**	**6**	**2.5**	**4**	**2**	**2**	**4**	**2**	**5**	**4**	**1**	**4.4**
Oct-12	**2.83**	**6**	**3**	**4.33**	**1.67**	**1.25**	**1**	**1.67**	**4.8**	**2.25**	**1**	**4**

6. Prediction of relationship between surface and ground water

6.1 Prati index:

This index is well-known method as well as one of the most effective tools to reduce the huge data into a single value which predict the condition of the water body and we will not need to go through the entire data. It offers a simple, stable, reproducible unit of measure and communicate information of water quality to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of surface water. We will use water quality index to assess the water quality of Shahpura lake. As it provides a single number that will express overall water quality at a certain location and time based on pollution indicator water quality parameters. The objective of prati index is to turn water quality data into information that is understandable and usable by the public. Following results are observed:

The site S-1 comes under upstream North West. There is one site G-1 upstream North West around S-1.According to prati index site S-1 has been assigned **Class-4** indicating that the water is bad or polluted. This may be due to the sewage water being discharged through this Nala.

G-1 site has been assigned **Class-3** which indicating moderate type of pollution. This site located around S-1, the pollution at G-1 may be due to the sewage water from the Nala in to the G.W.

Site S-2 there are three sites G-02,Pz-1B,Pz-02 around this site. All these sites come under upstream North East. The site S-2 has been assigned **Class-4** indicating that the water is bad or polluted. This may be due to Nala flowing nearby.

Site G-2,Pz-1B,Pz-02 has been assigned **Class-2** indicating that the water is good with slightly pollution.

Site S-3 there are one site G-3 around this site. Both sites come under upstream North East. The site S-3 has been assigned **Class-3** indicating that the water is moderately polluted. High algal growth found in this area & washing of clothes is being done here.

G-3 site has been assigned Class-2 indicating the water is good with slightly pollution.

Site S-4 there are three sites G-4, Pz-3, and Pz-4 around this site. All these sites come under upstream North East. The site S-4 has been assigned **Class-3** indicating that the water is moderately polluted. Slum area is found in front of Administrative academy.

G-4 site has been assigned **Class-3** indicating that the water is moderately polluted. This site located near slum area of in front of Administrative academy. The slightly pollution at G-4 may be due slum area.

Pz-3 and Pz-4 have been assigned **Class-3** indicating that the water is moderately polluted.

Site S-5 there are one site G-5 around this site. Both sites come under upstream South East. The site S-5 has been assigned **Class-3** indicating that the water is moderately polluted.

G-5 site has been assigned **Class-2** indicating that the water is good with slight pollution.

Site S-6 comes under downstream south East. Site S-6 has been assigned **Class-3** which is indicating water is moderately polluted because this is the confluence point of Shahpura sewage Nala.

Site S-7 there are Two sites G-7A,and G-7B around this site. All these sites come under Downstream South East. The site S-7 has been assigned **Class-3** indicating that the water is moderately polluted. This may be due to the waste material thrown in this area.

G-7Aand G-7B Both these sites have been assigned **Class-2** indicating that the water is slightly polluted.

Site-8 comes under upstream center. Site has been assigned Class-3 which is indicating that the water is moderately polluted. This may be due to the water from the Nala mix with lake water, here pollution is comparatively less than the surrounding area and fishing activity is undertaking here.

Site S-9 there are three sites G-9, Pz-9A, and Pz-9B around this site. All these sites come under upstream North West. The site S-9 has been assigned **Class-3** indicating that the water is moderately polluted. This may be due to the waste material from the surrounding urban area.

G-9 site has been assigned **Class-2** indicating that the water is good with slightly pollution.

Pz-9A and Pz-9B have been assigned **Class-3** indicating that the water is moderately polluted.

Site S-9 there are three sites G-10, Pz-10A, and Pz-10B around this site. All these sites come under Downstream North West. The site S-10 has been assigned **Class-3** indicating that the water is moderately polluted. This may be due to mixing of Nala water in this area.

G-10 site has been assigned **Class-3** indicating that the water is moderately polluted

Pz-10A and Pz-10B have been assigned **Class-3** indicating that the water is moderately polluted

Site S-11 there are three sites G-11A, Pz-11B, and G-11C around this site. All these sites come under Downstream South West. The site S-11 has been assigned **Class-3** indicating that the water is moderately polluted.

G-11A site has been assigned **Class-3** indicating that the water is moderately polluted

G-11B and G-11C both sites have been assigned **Class-2** indicating that the water is good slightly polluted.

Site S-12 there are four sites G-12A,G-12B,G-12C and Pz-12 around this site. All these sites come under Downstream South West. The site S-12 has been assigned **Class-3** indicating that the water is moderately polluted.

G-12A, G-12B, G-12C andPz-12 sites have been assigned **Class-2** indicating that the water is good with slightly polluted.

Site S-13 there are one site G-13 around this site. Both sites come under downstream Southwest. The site S-13 has been assigned **Class-3** indicating that the water is moderately polluted. It may be due sewage water from the Nala and through of waste material here.

G-13has been assigned **Class-2** indicating that the water is good,slightly polluted.

Table 20: Prati index values of shoreline, peizometer and ground water in Shahpura lake basin.

Surface water	Upstream					Down stream		Upstream		Down stream			
	NW	NE			SE	SE	SE	Cente	NW	NW	SW		
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13
Year	Average												
2010	20.1	20.7	17.0	17.1	15.7	18.3	14.6	16.1	19.4	15.6	13.9	13.2	17.3
2011	20.7	20.3	17.0	14.7	14.1	16.0	13.9	15.5	14.3	14.3	13.7	14.4	15.9
2012	20.2	20.3	18.3	13.9	14.3	14.7	15.5	15.0	15.0	15.2	15.2	17.0	16.7
	Maximum												
2010	23.0	23.0	20.0	19.0	19.0	22.0	21.0	20.0	21.0	17.0	15.0	16.0	19.0
2011	23.0	24.0	21.0	20.0	18.0	23.0	18.0	20.0	19.0	21.0	18.0	21.0	19.0
2012	23.0	22.0	21.0	16.0	17.0	18.0	17.0	17.0	18.0	17.0	18.0	18.0	19.0

Peizometer		Upstream			Upstream					Upstream		Down stream				Down stream	
		NE			NE					NW		NW				NW	
		PZ-1B & PZ-2			PZ- 3 & PZ- 4					PZ-9A	PZ- 9B	PZ-10	PZ-10			PZ-12	
	Average																
2010		7	7.99		10.66	10.33				10.33	10.66	7.33	7.66			9.66	
2011		9	8.25		10.5	10.25				10.5	10.5	11.25	10.75			9.5	
	Maximum																
2010		7	12		11	13				11	11	8	9			11	
2011		9	10		12	12				12	11	13	13			11	

Ground water	Upstream						Down stream		Upstream	Down stream						
	NW	NE			SE		SE		NW	NW	SW					
	G-1	G-2	G-3	G-4	G-5		G-7B	G-7B	G-9	G-10	G-11A,	G-11B	G-11C	G-12A	G-12B	G-12C	G-13
	Average																
2010	8	5	5.8	6.1	3.7		4	5	8.7	8.2	9.5	6	5.8	5	6.3	5.5	5.5
2011	8.3	5.2	6.4	7.1	5.4		6.6	5.6	6.1	7.9	9.3	5.6	5.8	5.8	6.2	6	6.1
2012	7.8	5.3	6.1	7.6	5		6.6	6.6	6.6	6.8	9	7.8	6.6	6.5	7.1	6.6	6.5
	Maximum																
2010	10	6	7	8	4		4	5	9	9	11	6	8	5	7	6	7
2011	9	6	8	8	6		8	6	8	8	11	9	6	7	8	6	7
2012	10	6	8	8	5		9	8	9	8	9	10	8	8	9	8	7

6.2 Correlation of surface water quality with Ground water quality:

PCA was executed on 6 variables for Shahpura lake with 51 sampling sites in order to identify variation in water quality. In this we evaluated the relationship between surface and ground water. We used pollution indicative parameters to evaluate the ground water contamination.

The Principal Component Analysis or redundancy analysis is an ordination technique with an implied Euclidian distance. It represents the first principal component and explains most of the plots variability. The second component will be located perpendicularly to the first one and accounts for the variability not explained by the first component. The PCA diagram shows the slope of the parameters in relation to the principal component as parameters or points. Since the environmental variables have a linear relationship to the components, they point to the direction to determine their preferred intensity to the variable.

The analysis of principal component from surface water and ground water sites using lomnological and ground water quality data of pH, conductivity, nitrate, phosphate, COD and Total hardness revealed 4 axis (Fig.152). The PC1 axis was surface water sites S-2, S-3, S-4, S-5 and S-6, giving high positive correlation with G-5, G-12A and PZ-2 ground water sites. PC2 showed S-13 positive loading with G-7A, G-9, G-10, G-11A, G-11B, G11C, G-12B and G-13. PC3 showed high negative loading with ground water sites namely G-01, G-02, G-03 and G-07B and PC4 showed negative relation surface sites S-8, S-9 and S-10 with PZ-3, PZ-4, PZ-5, PZ-6, PZ-7 and PZ-8 ground water sites (experimental tube wells).

Fig 152: Principal Component Analysis of Shahpura Lake on the basis of Limnological, Ground and Peizometer data.

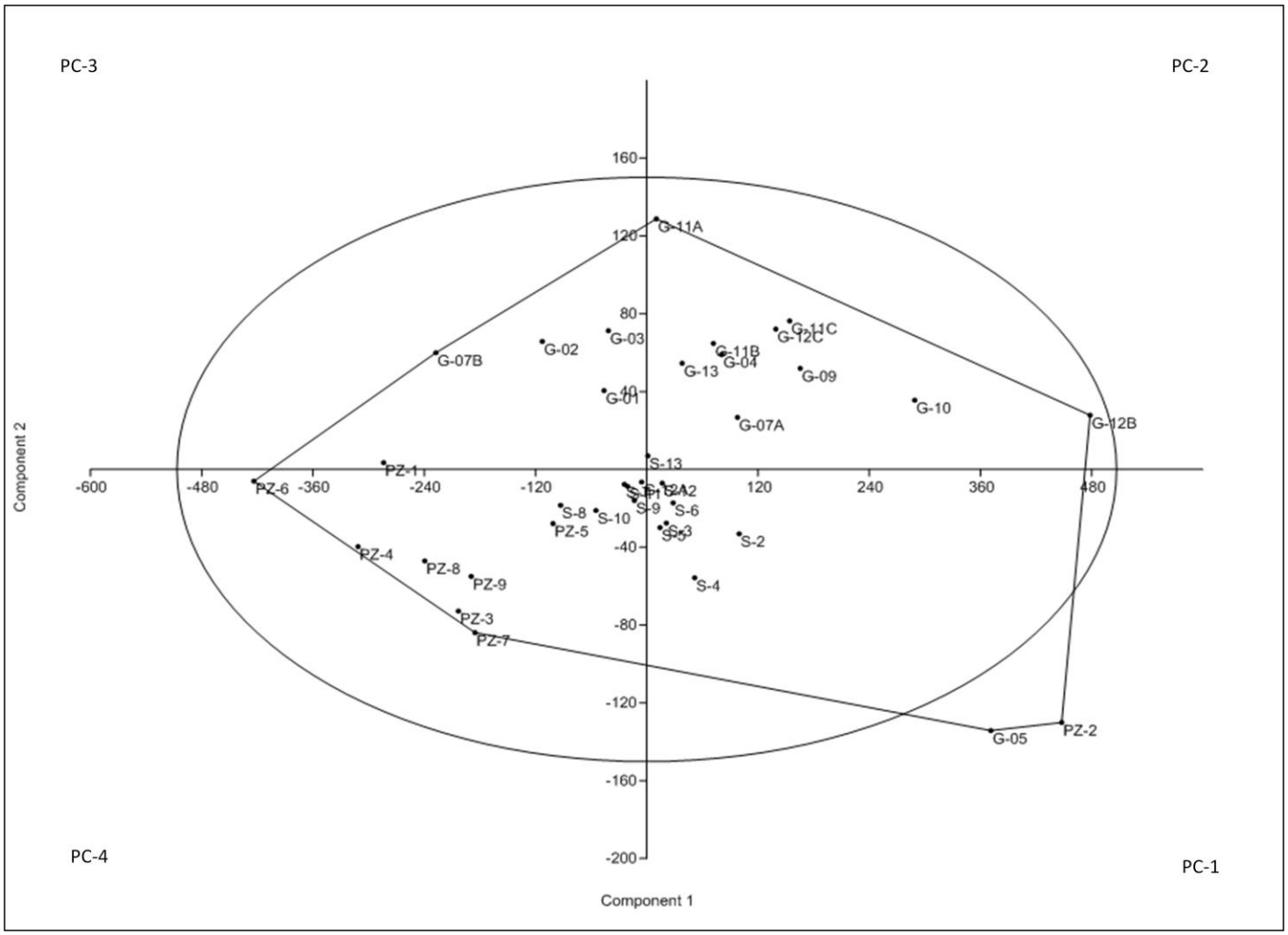


Plate –III: Survey, sampling lake and ground water and analysis of PDS work








7. Conclusion

Based on the objective for a long term monitoring mechanism to keep vigil on progression of water pollution by studying systematic & periodically physic-chemical parameters, biological and sediment of Shahpura lake basin the following conclusion is reported:.

- Discharge of untreated sewage is spoiling the ecosystem of the water body.
- Increasing concentration of nitrogen and phosphate nutrients has led to eutrophication of the water body.
- Presence of ammoniacal nitrogen has made the water body toxic.
- Increased level of organic matter in ground water aquifer establishes intrusion of sewage water.
- A continuous degradation in biological character of the water body has been observed as also evident in the results of Nygard Index, Carlson Trophic Status Index and BMWP scoring using macroinvertebrates.
- It has been found that the Indian major carps (Catla, Rohu and Mrigal) and other economically benefitted fish productivity are low. Whereas *Tilapia mossambica* is flourishing well because it grows well in the sewage polluted water.
- Due to increase in nutrients level, sediment quality has also been enhanced. Therefore production of algal biomass is found very high.
- The correlation of chemical properties (presence of nutrients and organic matter) between surface water and ground water shows the ingress of pollutants from sewage contaminated lake.
- The medium separating the lake water and ground water aquifer is contact of Vindhyan Sand stone and Deccan Trap Basalt. Cracks and fractures of Basalt may be the possible reason for intrusion of lake water contaminants in to ground water.
- Though the socio economical and educational status of the urban population residing around the study area belongs to high socio economical class and has knowledge about the environment degradation and water quality, they are forced to use the contaminated ground water.

8. Recommendation for further study and policy makers

- Detailed study of area for finding aquiclude (non permeable) geological strata shall be selected for construction of an embracement in any watershed proposed for the collection of domestic sewerage. This will protect the aquifer from leaching of contaminants in its catchment.
- Treatment of sewage water before its joining in any water body shall be made mandatory.
- Establishing treatment plant like gravel bed treatment or Root zone treatment for improving quality of water resources within water body.
- The washing area at upstream of lake should be shifted to downstream outside wastewier.
- Aeration in the lake is needed to increase the fish productivity.
- Tilapia fish is considered to be harmful for natural pond ecosystem and banned for culture in India. Therefore tilapia shall be removed from the water body to improve the productivity of cultivable species stock.