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To evaluate the water quality status and responsible factors for variation in Anchar Lake, Kashmir

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***Abstract**: The present study was carried out to evaluate the water quality status of Anchar lake Kashmir whole year from January 2013 to December 2013. Anchar lake, an urban shallow basin lake with a maximum depth of 2.6 meters was getting modified as a result of cultural eutrophication due to anthropogenic pressure, siltation and the effluent released from Sheri-Kashmir Institute of Medical Sciences (SKIMS). The physico-chemical characteristics assessed at seven selected sites for pH, conductivity, temperature, depth, dissolved oxygen (DO), Total hardness, calcium hardness, magnesium hardness, free CO_2, sulphate, phosphate, iron, ammonical nitrogen, sodium and potassium. Result shows positive correlation among all the physico-chemical parameters except DO. The study reveals that site 7 near SKIMS was highly nutrient rich with respect to other sites.*

I. Introduction

Water is the Universal solvent, abundant and useful component, without it life is impossible. These water bodies are not only important for water, but also for their ecological importance as they provide habitat to aquatic flora and fauna including different species of birds. They may also comprise an important component for sustainable tourism and recreation. At present water resources are in a serious problem due to encroachment, unplanned urbanization and industrialization (Singh, et. al., 2002). Environmental status of lakes all over the World is in varying degrees of degradation. The Kashmir valley, in India is famous for its high mountain reaching to a height of 6000 meters, their elevations and depressions have created numerous, high altitude, fresh water lakes- The urban lakes of Kashmir including Anchar Lake are facing a serious threat of encroachment due to anthropogenic pressures resulting in their gradual eutrophication and degradation. The Anchar Lake is situated at an altitude of 1583 m above sea level and lies between 34°-20' to 34°-36'N and 74°-82' to 74°-85' E and is situated in semi urban conditions. The lake is located near Soura at a distance of 14kms north-west of Srinagar and is shallow with single basin. The lake is fed by Sindh Nallah and numerous small channels. Anchar Lake receives water also from Dal Lake through a Nallah named Amir Khan via Khushalsar Lake. Large areas surrounding the lake have been reclaimed for agricultural and habitational purposes. Paddy fields are present on its North- Western side. The lake is undergoing considerable shrinkage mainly due to human activities.
The objectives of the present study were to assess water quality status, factors responsible for variation and effect of effluents of SKIMS on water quality of the lake.

II. Materials and methods

The lake has an area of 4.26 Km^2 with a maximum depth of 2.6 meter (Fig.1). The lake was divided into seven sampling stations namely Sind out flow (Site 1), Center of lake (Site 2), Sind inflow (Site 3), Sandgul (Site 4), Manzcul (Site 5), Sangam (Site 6) and SKIMS (Site 7).

Water samples were collected on monthly basis from the lake at different selected sites in one liter polyethylene bottles properly cleaned and were analysed in laboratory for different physicochemical parameters as per APHA (1998).

Parameters like depth, transparency, temperature, pH, conductivity and dissolved oxygen were recorded at sampling stations. Parameters like calcium, magnesium, free carbon dioxide, sulphate, phosphate, iron, ammonical nitrogen, sodium, potassium and hardness were analysed in laboratory. Study period were divided into four phase i.e. Phase Ist from January to March; Phase IInd from April to June; Phase IIIrd from July to September; Phase IVth from October to December.

III. Results and Discussion

The water temperature ranges between 10±0.5ºC to 21±1ºC. The minimum of 10ºC was recorded at sites 1,3,5,7 and maximum 21ºC at site 2 during summer season (Fig.2). The high water temperature recorded is the result of low water depth and consequently the volume of water in contact with air as observed by Sankar *et al., (*2010) and Bhaskar et. al. (2003) in other eutrophic water bodies.

The water depth ranged about 0.60±0.02 meters to 2.5±0.2 meters. The minimum depth of 0.60 was recorded at site 7 during phase Ist and the highest (2.52±0.22 m) at site 1 during phase IIIrd (Fig. 3). The depth does not show variation among the different sites. The minimum depth of 0.6 meters was observed at site 7 and is related to more erosion in catchment area resulting in accumulation of sediments, thus reducing the depth. The variation in the depth of water body may be attributed to the excessive varied siltation, shallow waters have been associated with production systems.

The pH of water fluctuated from 7.7±0.1 to 8.5±0.1. The lowest value 7.7±0.2 was recorded during phase Ist, IIIrd & IVth and the highest value 8.5±0.1 at site 7 during phase IInd (Fig. 4). The high pH values are probably due to the production of salicylic acid by the hydrolysis of silicates in the rock beds of the catchment areas (Sankar *et al.,* 2010)). It may also be attributed due to increased organic compound degradation which is high in the lake. The higher value of pH of (8.5) coincides with the period of higher photosynthetic activity by macrophytes which results in decrease of H^+ concentration.

The conductivity ranged from 275±5 to 559±10. The minimum value of 275±5 was recorded at site 3 during phase IVth and maximum value of 559±10 was recorded at site 7 during phase IVth (Fig.5). The overall high conductivity of Anchar Lake depicted high ionic concentration with maximum at site 7. The higher values were related to the abundance of nutrients released from the wastewaters, in addition to the release from decomposition process of organic matter (macrophytes and animals). Increased electrical conductivity is regarded as pollution indicator in shallow lakes (Das *et al.,* 2006).

The transparency ranged from 0.2±0.05 meters to 1.28±0.1 meters. The minimum value 0.25 meters was recorded at site 7 during phase IVth and maximum value of 1.28 at site 1 during phase IVth. The low transparency of lake water is due to siltation and blooms of planktonic algae (Thilaga et.al. 2005; Akuskar and Gaikwad 2006). The transparency of 0.2 meters clearly depicts silt load in Lake.

The total hardness exhibited a range of 168±5 mg/l to 555±13 mg/l. The minimum value of 168±5 mg/l was recorded at site 4 during phase IVth while as the maximum 555±13 mg/l was recorded at site 7 during phase IInd (Fig. 6). The higher value is attributed to the inflow of effluent from SKIMS hospital where hardness was 555mg/L. The calcium, magnesium showed a decline from February to May this is probably due to assimilation of cations (Ca and Mg) by macrophytes Bhandari, N. S. and Nayal, K. 2008 were also reported decrease in cation concentration due to the accumulation by macrophytes.

The calcium content ranged from 33±3 mg/l to 76.3±8 mg/l. The minimum 33±3mg/l was recorded at site 1 during phase IVth and maximum 76.3±8 mg/l at site 7 during phase IInd (Fig. 7). The magnesium value ranged from 19±2 mg/l to 50±6 mg/l. The minimum value of 19±2 mg/l was observed at site 4 during phase IVth and maximum value of 50±6 mg/l was recorded at site 7 during phase IInd (Fig. 8) The source of calcium and magnesium can be attributed to presence of lime stone in catchment areas (Najar and Khan 2011a). However the low Magnesium content was possibly due to its up lake by the plants (Bhandari, N. S. and Nayal, K. 2008) there by confirming 3:1 for Ca and Mg recorded for other water bodies (Thilaga et.al., 2005; Akuskar, S. K. and Gaikwad, A.V. 2006).

The value of alkalinity varied from 116 ±5 mg/l to 412 ±10 mg/l. The minimum value of 116 ±5 mg/l was recorded at site 3 and 5 during phase IVth and maximum value of 412±10 mg/l was recorded at site 7 in phase Ist (Fig. 9).Alkalinity of lake was mostly found to be greater than 140 mg/l with maximum at site 7 and therefore the water can be considered as nutrient rich (Mishra, A. and Tripathi, B. D., 2007). The excessive increase in the concentration of total alkalinity at site 7 (412 mg/l) may be attributed to chemicals present in the effluent which are drained into the lake from SKIMS.

The chloride concentration varied from 22±1.2 mg/l to 60 ±3.3 mg/l. The minimum concentration of 22±1.2 mg/l was at site 2 and 3 during phase Ist and maximum 60±3.3 was at site 7 during phase IInd (Fig. 10). Chloride concentration is an index of eutrophication (Kumar et. al. 2006) and also pollution caused by sewage and other waste outlets (Thilaga et. al. 2005; Shyamala, et. al. 2008; Mishra, A. and Tripathi, B. D. 2007). The high chloride concentration of the lake may be related to the presence of large amounts of organic matter of both allochthonous and autochthonous origin (Nath, D. and Srivastvava, N. P., 2001; Pandit 1999). It is clear that even a moderate level of chlorides cause sufficient water pollution. The highest concentration was at SKIMS site, an indicator of inorganic pollution, again owes its origin to the sewage wastes carrying detergents, sewage from human settlements and chemical wastes of the SKIMS drained into the lake (Shamim et. al. 2001 and Singh, R. K. and Singh, K. N. 2007; Fokmare, A. K. and Musaddiq, M. (2002).

The CO_2 values vary from 12±0.9mg/l to 32.4±3mg/l. The minimum value 12±0.9mg/l was recorded at site 1and 2 during phase Ist and maximum 32.4±3mg/l was recorded at site 7 during phase IIIrd (Fig. 11). The carbon dioxide content of water depends upon the water temperature, depth, rate of respiration, decomposition of organic matter, chemical nature of the bottom and geographical features of the terrain surrounding the water body (Sakhare and Joshi 2002). During present study the higher value of free CO_2 was recorded at site 7 and lower value was recorded at site 1 and 2. The high value may be related to the municipal effluent and hospital waste from the SKIMS. Study of Najar and Khan (2011a) also reported wastewaters as main source of organic waste.

The dissolved Oxygen of the water body ranges about 3.1±0.5 mg/l to 5.5±0.2mg/l with minimum value 3.1±0.5mg/l was recorded at site 7 during phase IVth and highest value of 5.5±0.2mg/l was recorded at site 1 during phase Ist (Fig. 12). The dissolved oxygen in water is temperature dependant (Khare and Jadav., 2008). Low value of dissolved oxygen is an indication of a tendency towards an anoxic condition. However in case of Anchar Lake the overall moderate content of dissolved oxygen correlates with the growth and abundance of macrophytes and phytoplankton of the lake releasing oxygen during photosynthesis. The low dissolved oxygen was recorded at site 7 which is mainly due to effluents released from SKIMS, adding large quantity of organic wastes which consume the dissolved oxygen. The values further deplete during summers because at high temperature, the oxygen holding capacity of water decreases (Shyamala et.al. 2008). Present observations are in agreement with Yogesh Shastri and Pendse (2001) and Shanthi et. al. (2002) as they reported domestic wastes as main source of pollution resulting anoxic conditions in water bodies.

The sodium concentration ranged from 01±0.01 mg/l to 14±2mg/l with upper value of 14±2 mg/l was recorded at site 7 during phase Ist and lower value of 01 ± 0.01 mg/l was recorded at sites (1, 2, 3) during phase IInd; IIIrd and IVth respectively. The high content of sodium in the fresh waters owing its source to domestic sewage and effluents from SKIMS. Sharma *et al.* (2012) also reported domestic sewage and effluent as main source of sodium.

The Potassium concentration varied from 01±0.01mg/l to 13±1.1mg/l with a maximum value of 13±1.1mg/l was recorded at site 7 during phase Ist and minimum value of 01±0.01mg/l was recorded at site 1 during phase IVth. The higher value of 13 mg/l goes beyond the permissible limit of 10 mg/L. Its higher values may be attributed to the agricultural runoff (Garg et. al. 2010).

The Phosphate values fluctuated from 123±2μg/l to 543±13μg/l. The site 3 exhibited a minimum value of 123±2μg/l during phase IVth and a maximum value of 543±13μg/l at site 7 during phase Ist. Phosphorus is regarded as a key element in eutrophication process (Fokmare, A. K. and Musaddiq, M. 2002) and raw sewage is the source of phosphates in different lakes (Agrawal, et. al. 2000). In case of Anchar Lake, the maximum phosphate showed gradual increase from site 1 to site 7 (SKIMS) where the concentration ranged from 520 to 543μg/l as the site is under fast influence. Further the higher values are attributed to the use of fertilizers in nearby agricultural fields. Similar results reported by Arvind Kumar (1995). Najar and Khan (2011a) also reported agricultural runoff as main source of pollution in Anchar Lake resulting in accelerated eutrophication phenomenon.

The Ammonical nitrogen concentration varied from 155±8μg/l to 512±11μg/l. The minimum value 155±8μg/l was recorded at site 2 during phase IVth and maximum value 512±11μg/l was recorded at site 7 during phase Ist. Ammonical nitrogen may be considered favorable for fish productivity. But higher values of ammonical nitrogen that lie in the range of 522 to 523□g/l at SKIMS site is an indication of organic pollution and thus the waters are favorable for prolific growth of obnoxious weeds like Salvinia natans (Magudeswaran, P.N. and Ramchandaran, T. (2007). Further higher values may be attributed due to domestic sewage that contributes nutrients to the lake (Qadri et al. 1999; Nath, D. and Srivastvava, N. P., 2001) and use of fertilizer in nearby agricultural fields.

The sulphate concentration showed a range of 61±1.9mg/l to 151±3.9mg/l. The minimum value of 61±1.9mg/l was recorded at site 4 during phase IVth and maximum value of 151.9± 3.9mg/l was recorded at site 7 during phase IInd. The presence of sulphate in water in higher concentration is undesirable. Sulphate exhibited variation among the sites. The highest values were found near the site of SKIMS. This may be due to the effluents containing sulphate that increases the concentration in lake. Purandara et al. (2003) Nath, D. and Srivastvava, N. P. (2001) also reported higher values of sulphate due to mineral weathering of bed rocks.

The iron concentration ranges from 131±2.1μg/l to 233±6.3μg/l. The minimum value 131± 2.1μg/l was recorded at site 4 during phase IVth and maximum value of 233±6.3μg/l was recorded at site 7 during phase Ist. Iron in drinking water may be due to its geological sources, domestic discharges and also the runoff from the nearby agricultural fields. The iron concentration during the study was high at site 7 (233), which may be reputed to the effluent discharge from SKIMS and also agricultural runoff from the nearby fields. Najar and Khan (2011a) also reported higher values of iron due to nearby agricultural fields.

IV. Conclusion

From the present study it is clear that the Anchar Lake is getting modified as a result of cultural eutrophication mainly from anthropogenic pressure, siltation and the effluents released from SKIMS complex. The condition of the lake has reached a critical stage from ecological angles and if proper conservation measures are not taken, the lake is likely to deteriorate further. Though the rate of pollution varies from site to site with maximum in area receiving wastewaters from SKIMS, yet the impacts has been actually observed throughout the lake resulting in undesirable changes being accompanied by wide environmental degradation.

The site 7 i.e. SKIMS has clearly indicated that there is adverse impact of effluents from SKIMS which are ultimately released into the lake in addition to the solid waste, sewage from human habitation. The site is highly nutrient rich with respect to other sites. Thus it is quite evident that the hospital effluent and sewage from human habitation have altered the lake chemistry and also the trophic status of the lake. In conclusion, it is quite convincing that the lake shows signs of accelerated eutrophication due to heavy anthropogenic pressure, siltation, effluents released from SKIMS and waste disposal into the lake.

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Table 1. Physicochemical characteristics of the Anchar Lake for the month of January to March 2013 (Phase Ist)

S.No	Parameter	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
1	Air temperature	°C	15	16	15	16	15	16	15
2	Water temperature	°C	10	11	10	11	10	11	10
3	Depth	m	2.45	2.4	1.21	1.2	0.75	1.8	0.6
4	pH		7.78	7.77	7.6	8.1	8	8	8.2
5	Conductivity	μ mhos	300	305	292	354	318	478	546
6	Transparency	m	1.2	1.1	0.76	0.9	0.56	0.75	0.29
7	Total hardness	mg/l	180	230	240	197	230	378	555
8	Calcium	mg/l	36	42	41	40	38	51	74
9	Magnesium	mg/l	24	22	23	21	24	33	45
10	Total alkalinity	mg/l	137	144	132	141	132	190	412
11	Chloride	mg/l	30	22	23	26	31	47	56
12	Free CO_2	mg/l	12	12	12.5	15	12.8	23.9	29
13	Dissolved Oxygen	mg/l	5.5	5	5.1	5	5	4	3.8
14	Sodium N^+	mg/l	3	3	2	4	11	9	14
15	Potassium K^+	mg/l	3	4	6	4	4	8	13
16	Phosphate	μg/l	171	161	166	145	278	521	543
17	Ammonical nitrogen	μg/l	221	212	234	245	321	434	512
18	Sulphate	mg/l	89	98	96	76	69	94	161
19	Iron Fe	μg/l	175	156	151	141	194	204	233

Table 2. Physicochemical characteristics of the Anchar Lake for the month of April to June 2013 (Phase IInd)

S.No	Parameter	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
1	Air temperature	°C	20	21	20	20	20	20	21
2	Water temperature	°C	15	16	15	15	15	15	16
3	Depth	m	2.46	2.43	1.24	1.21	0.762	1.82	0.62
4	pH	-	7.8	7.9	7.8	8.3	8	8.1	8.5
5	Conductivity	µ mhos	305	310	301	348	301	487.2	551
6	Transparency	m	1.25	1.16	0.77	0.89	0.56	0.77	0.25
7	Total hardness	mg/l	184	220	232	186	212	360	524
8	Calcium	mg/l	44	42.6	43.4	41	39.3	50.6	76.3
9	Magnesium	mg/l	25	23	25	24	27	35	50
10	Total alkalinity	mg/l	140	148	136	140	136	186	410
11	Chloride	mg/l	28	26	24	28	32	50	60
12	Free CO_2	mg/l	12.3	13.2	13.2	17.6	13.2	26.4	30.8
13	Dissolved oxygen	mg/l	5	4.8	4.9	4.8	4	3.8	3.2
14	Sodium N^+	mg/l	2	1	2	3	8	7	12
15	Potassium K^+	mg/l	2	3	4	4	3	9	12
16	Phosphate	µg/l	151	155	135	262	240	455	525
17	Ammonical nitrogen	µg/l	195	190	192	210	285	375	472
18	Sulphate	mg/l	74.2	96.2	93.3	72.3	66.3	90.9	151.9
19	Iron Fe	µg/l	150	145	145	142	182	198	210

Table 3. Physicochemical characteristics of the Anchar Lake for the month of July to September 2013 (Phase IIIrd)

S.No	Parameter	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
1	Air temperature	°C	24	23	24	23	24	24	24
2	Water temperature	°C	18	17	18	17	18	18	18
3	Depth	m	2.52	2.49	1.28	1.21	0.731	1.85	0.62
4	pH		7.7	7.9	7.7	8.4	8.1	8	8.3
5	Conductivity	µmhos	310	312	278	333	287	500	544
6	Transparency	m	1.25	1.06	0.72	0.85	0.54	0.7	0.22
7	Total hardness	mg/l	174	215	225	178	196	341	534
8	Calcium	mg/l	38.9	40	44.2	41.8	42	46	64
9	Magnesium	mg/l	27	24	24.8	23.5	27.7	35.4	48.2
10	Total alkalinity	mg/l	134	142	132	138	142	181	398
11	Chloride	mg/l	30	32	34	26	28	42	52
12	Free CO_2	mg/l	13.2	13.2	17.6	20.8	16.2	23.5	32.4
13	Dissolved Oxygen	mg/l	5.2	4.9	5.2	4.8	4.2	3.9	3.3
14	Sodium N^+	mg/l	2	1	1	2	12	8	13
15	Potassium K^+	mg/l	3	2	5	6	4	6	8
16	Phosphate	µg/l	152	156	132	265	242	455	520
17	Ammonical nitrogen	µg/l	188	185	190	215	280	370	468
18	Sulphate	mg/l	67.9	78	94.3	63	76	81	137
19	Iron Fe	µg/l	151	144	140	138	175	182	211

Table 4. Physicochemical characteristics of the Anchar Lake for the month of October to December 2013 (Phase IVth)

S.No	Parameter	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
1	Air temperature	°C	24	25	23	24	23	24	24
2	Water temperature	°C	20	21	19	20	19	20	20
3	Depth	m	2.48	2.45	1.24	1.24	0.79	1.86	0.6
4	pH		7.7	7.9	7.9	8.4	8	8.2	8.2
5	Conductivity	µ mhos	298	305	275	325	276	480	559
6	Transparency	m	1.28	1	0.7	0.8	0.51	0.7	0.2
7	Total hardness	mg/l	170	210	215	168	180	298	510
8	Calcium	mg/l	33	35	36	37	36	42	56
9	Magnesium	mg/l	23	21	21	19	23	30	41
10	Total alkalinity	mg/l	128	121	116	121	116	166	377
11	Chloride	mg/l	25	24	22	24	36	40	54
12	Free CO_2	mg/l	14	12	15.3	21	17.3	22	26
13	Dissolved oxygen	mg/l	4	4.1	4.2	4.3	3.8	3.4	3.1
14	Sodium N^+	mg/l	1	1	1	2	6	6	8
15	Potassium K^+	mg/l	1	2	3	3	3	4	6
16	Phosphate	µg/l	132	141	123	229	221	412	498
17	Ammonical nitrogen	µg/l	165	155	172	198	256	331	421
18	Sulphate	mg/l	66	71	89	61	62	73	121
19	Iron Fe	µg/l	144	140	137	131	161	163	185

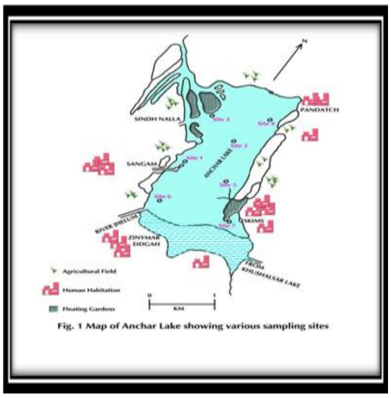

Fig. 1 Map of Anchar Lake showing various sampling sites

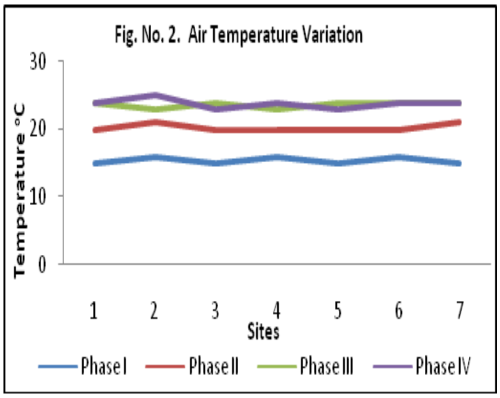

Fig. No. 2. Air Temperature Variation

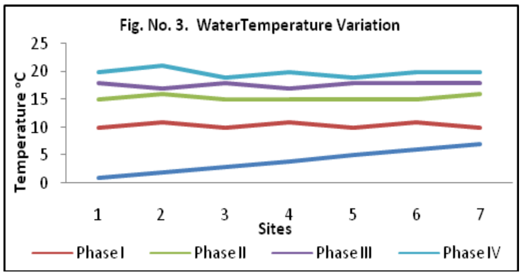

Fig. No. 3. WaterTemperature Variation

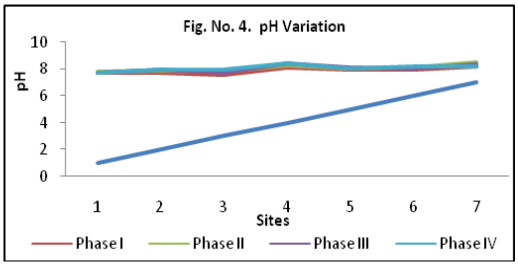

Fig. No. 4. pH Variation

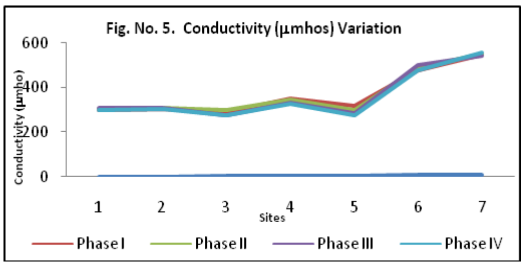

Fig. No. 5. Conductivity (µmhos) Variation

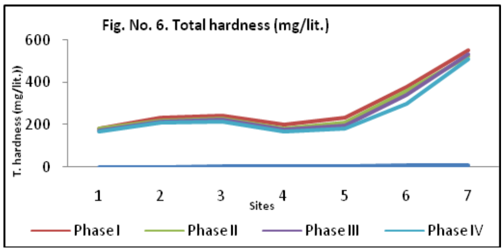

Fig. No. 6. Total hardness (mg/lit.)

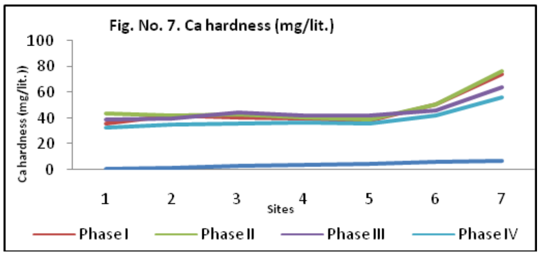

Fig. No. 7. Ca hardness (mg/lit.)

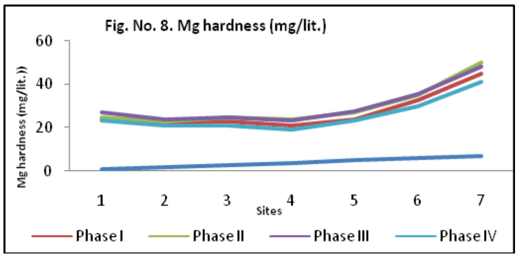

Fig. No. 8. Mg hardness (mg/lit.)

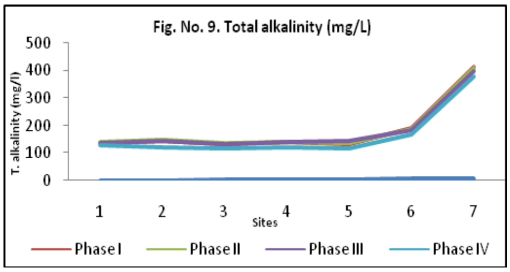

Fig. No. 9. Total alkalinity (mg/L)

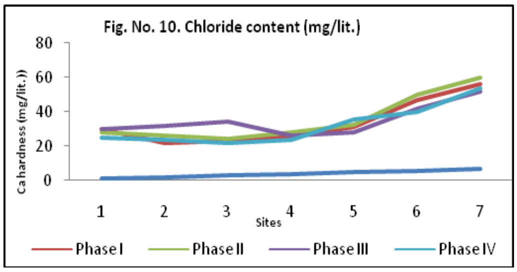

Fig. No. 10. Chloride content (mg/lit.)

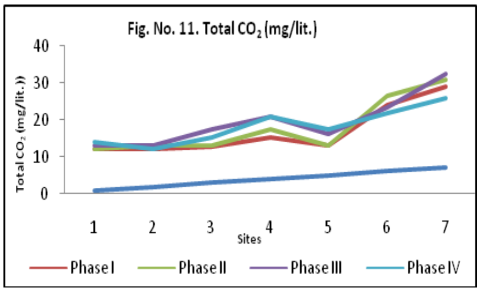

Fig. No. 11. Total CO_2 (mg/lit.)

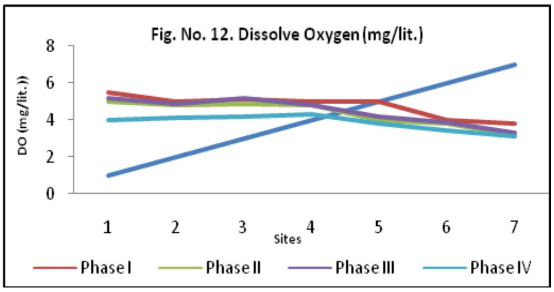

Fig. No. 12. Dissolve Oxygen (mg/lit.)