A STUDY OF PHYSICO-CHEMICAL PARAMETERS OF KRISHNA RIVER WATER PARTICULARLY IN WESTERN MAHARASHTRA

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ABSTRACT
The physico-chemical parameters of Krishna river water was studied in the month of May2008. Nine samples were collected from different locations. The parameters like pH, EC, TDS, TS, BOD and DO etc. were determined in research lab of DKTE, Ichalkaranji. The results obtained were compared with standards of ICMR and WHO. From the results it was found that the most of the parameters of Krishna river water are within the permissible limit of ICMR and WHO.
Keywords:

INTRODUCTION

Environment is defined as one's surroundings. The global environment consists of atmosphere, the hydrosphere, and the lithosphere, in which life sustaining resources on the earth are contained. Atmosphere is the mixture of gases extending outward from the surface of earth; evolved from element of earth that were gasified during its formation and metamorphosis. The hydrosphere is made up of the oceans, the lakes and streams and the shallow groundwater bodies that interflow with the surface water. The lithosphere is the soil mantle that wraps the core of the earth.

The biosphere, a thin shell that encapsulates the earth, is made up of the atmosphere and lithosphere adjacent to the surface of the earth together with the hydrosphere. Life sustaining resources like air, water and food are withdrawn from the biosphere.

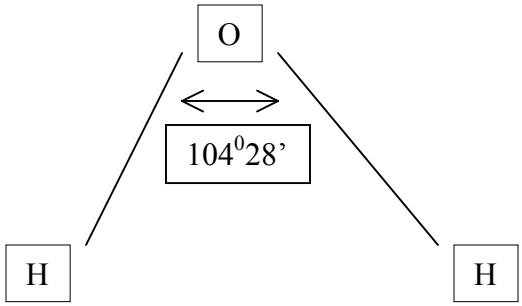
In a natural state, earth's life forms live in equilibrium with their environment. Humans have the ability to gather resources from beyond their immediate surroundings and process those resources into different more versatile forms. Anthropogenic, a human induced pollutants, have overloaded the system. As early societies were concerned with meeting natural needs, the overloading came relatively late in the course of human interaction with environment.

Early human used natural resources to satisfy their needs for air, water, food and shelter. These natural resources were readily available in the biosphere.

Water is most important chemical compound for the perpetuation of life on this planet. It is not only essential for lives but also important chemical compound from engineering point of view. Nearly 2/3 portion of this planet is occupied by water. It is present in three physical forms e. g. Solid, Liquid and gaseous. It has many unique properties. It is the compound which becomes rarer on solidification. It finds extensive use in the field of agriculture, hydro electric power generation and air conditioning.

Science of Water:

It is the important chemical compound present on earth which remains in liquid state over long range i. e. 0^0 to 100^0 C. Hence this compound can easily used as the solvent at various temperatures. It is excellent solvent for inorganic chemicals. This is because of its polar nature. It is having bent structure with bond angle $104^0$28'. The molecular structure of water is



Because of polar nature there is force of attraction between any ion and that end of H_2O molecule which is of opposite sign.

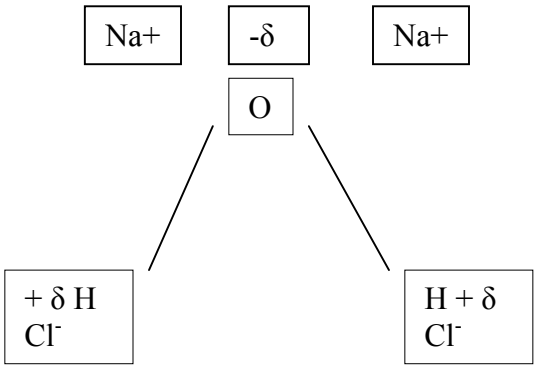


Fig.-1 ; Hydrated Na^+ ions that are in lower energy state.

This is due to ion dipole force of attraction. The force of attraction between ions and dipolar H_2O molecule forms hydrated ions which are lower in energy than the separate ions and water molecule.Water is the most important inorganic compound which plays vital role in sustaining life on earth and for development of civilization It constitutes about two third of the earth surface. Based on salinity, it can be broadly divided into ocean (97%) and fresh water (3%). Most of the latter are not accessible because about 87% of it is locked in the ice-cap and glacier atmosphere, soil and in the deep underground (Paul and Misra 2004).

Pollution parameters have been classified as physical, chemical and biological on the basis of analytical tests. Physical parameters include $_P$H, temperature, colour, turbidity, conductivity, suspended matter, and dissolved matter. Chemical parameters include inorganic salts, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrogen, Alkalinity, Chloride Content, Hardness of water, and different heavy metal ions present in water. Biological parameters include specific diversity, pathogens, and bioassay etc.

The quality of water need to be evaluated thoroughly to generate base line information for welfare of society. Niranjan Babu *et. al*. has explained health problems identified in developing urban areas.[1] It becomes important to determine the quality of water so that the suitability of water for drinking purpose, agriculture purpose and industrial purpose can be evaluated. Vijay Deshpande *et al* have classified water based upon its extent of pollution. The quality of particular water is determined by its Physico-Chemical properties.

Most of Indian Rivers water is polluted. The level of harmful element is found to increasing in all rivers. So, an attempt is made to study the physico-chemical parameters of Krishna river water.

In the present study the water of Krishna River at Sangli and Kolhapur District has been analyzed.

The main objective of study is
1) To evaluate the physico-chemical properties of Krishna river water from Sangli to Narsingwadi.
2) To compare the results with WHO norms and ICMR norms.
3) To suggest methods of purification if required.

TOPOGRAPHICAL STUDY OF AREA

The Krishna River is the second largest eastward draining, Perennial River in the Peninsular India. The River Krishna drains an area of 258,948 km^2, which is nearly 8% of the total geo-graphical area of the country. There are about 25 towns within the basin with the population more than hundred thousands. The average annual rainfall in the river basin is about 780 mm. The wet seasons sets in by the middle of June and withdraws by the middle of October. About 90% of the rainfall occurs during the wet season (June-October) and during the rest of the year (dry season) there is very little rainfall with no regular pattern.. The important land uses include agricultural land use (double crop – 35 %; single crop – 25 %), forests (15%), waste land (15%) and mixed land use (10%) .The predominant soils in the area are sandy loams and loams. The river reach between the monitoring stations is approximately 35 km long with two tributaries joining the river. The sampling station includes nine different locations from Kolhapur and Sangli districts of Maharashtra. The villages are Sangli, Haripur, Ankali, Udgaon, Arjunwad, Ghalwad, Shirti, Hasur and Narsingwadi.

EXPERIMENTAL

For quantitative analysis of Krishna River water, various samples were collected from about 35 Km stretch in between Sangli and Narsingwadi .The water has been collected from epilimnion during day time. Sample method is same as suggested in APHA, Methods for collection and analysis of water samples. Sampling is done at each station in polythene bottles of two-liter capacity. Sampling has been done in the month of January. The samples have been analyzed in the P.G. laboratory of DKTE Society's Textile and Engineering Institute, Ichalkaranji. The analysis is carried out for determination of physico-chemical properties of Krishna River water such as: pH, EC, total hardness, permanent hardness, chloride content, alkalinity, conductivity, temperature, percentage DO, turbidity, total dissolved solid, total suspended solid, sulphate content, Sodium, Potassium, Iron, Manganese, Zinc, Copper etc.
Physicochemical parameters of these samples were determined by using standard procedure[2-8].

1. **pH:** The pH is determined by Elico, model LI.120 Digital pH meter which gives direct value of pH.
2. **Conductivity:**The conductivity is determined by using digital conductivity meter. The Conductivity meter used is Lavibond made Senso Direct Con.200.
3. **Turbidity:** It can be determined by using turbidity meter.
4. **Total Solid:**Total solid consists of suspended solid & dissolved solid .This is determined by weight difference method. The 50 ml water sample has been taken in evaporating dish. The total water is evaporated. Whatever total solid matter is present gets accumulated at the bottom of the evaporating dish. After cooling the evaporating dish to room temperature it is again weighed. By weight difference method the total solid present in water is determined.
5. **Total Dissolved Solid:** The 50 ml of water sample is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. Further it is heated and water is totally evaporated. Whatever dissolved solid matter is present gets accumulated at the bottom of evaporating dish. The evaporating dish is cooled and weighed. By weight difference method the total dissolved solid is determined.
6. **Total Suspended solid:** This can be determined by the weight difference of total solid and total dissolved solid. TSS =TS –TDS

7. **Total Hardness:** The 50 ml water sample is titrated against 0.01M EDTA (Disodium Salt) solution by using EBT as an indicator. The EDTA of Qualigens is used with 98% purity. This gives the total hardness of water.
8. **Permanent Hardness:** The 250 ml water sample is boiled to reduce the volume to 100 ml. It is filtered through ordinary filter paper. This results in removal of temporary hardness. The filtrate is diluted to 250 ml with doubly distilled water. Permanent hardness is determined as above. . Now it is possible to evaluate the temporary hardness of the water.
9. **Alkalinity:** The alkalinity of water sample is determined by titrating it against standard acid solution using indicators like phenolphthalein and methyl orange.
10. **Chloride content:** The chloride content of water sample is determined by titrating the water sample against 0.02M silver nitrate solution using potassium chromate as an indicator.
11. **Sulphate content :**The sulphate content in the water sample is determined by using nephelometer.
12. **Metal Ions:**Metal ions are detected by flame photometry and atomic absorption Spectroscopy. The absorption of energy by ground state atoms in the gaseous state forms the basis of atomic absorption spectroscopy.When a quantitative analysis is to be performed, the sample is atomized and the absorption is measured exactly in same condition.
13. **Dissolved Oxygen:** The percentage of DO is determined by using Lavibond made Senso Direct Oxi.200.

RESULTS AND DISCUSSION

1. **pH**:It is found that pH of the river water slightly varies in studied locations.This variation is due to change in alkalinity of water sample. The pH value ranges from 7.5 to 7.8 units. The pH is graphically represented in Fig No. 3
2. **Electrical Conductivity:**It is found that Electrical conductivity of river water constantly goes on decreasing from Sangli town up to village Ghalwad. The conductivity varies from 194.5 μS to 1030 μS.The constant decrease in conductivity indicates that there must be reduction in number of dissolved inorganic salts. The conductivity of Krishna River water at Narsingwadi site is increased. This increase may be due to the effects of various religious activities performed at river site. The electrical conductivity is graphically represented in Fig No.4.
3. **Total Hardness:** In the present study it is found that hardness of river water is constantly decreasing along with the downstream path of river. The hardness of water depends upon dissolved salts present in water. It is having maximum hardness at the origin of the river. The decrease in hardness is due to the adsorption of common inorganic salts like Calcium Bicarbonate, Magnesium Carbonate present in water. Total Hardness ranges from 30 ppm to 65 ppm. It is having minimum value at Arjunwad and maximum value of 65 ppm at Narsingwadi. In the present study hardness due to magnesium is the maximum at Narsingwadi site. The increase in hardness may be due to the domestic activities like washing clothes, animals, vehicles etc. done at the river site. If magnesium content exceeds 50 ppm then water is unsuitable for drinking purpose and it may be laxative. Magnesium is generally found in the form of sulphate. Total hardness is graphically shown in Fig.5.
4. **Chloride Contents:**The analysis of water samples shows the irregular variation in Chloride content.. The chloride content is within the permissible limit of Indian Standards. Chloride content is minimum at Udgaon i. e3.4 ppm and maximum at Ankali that is 36.9ppm. The high amount of chloride at Hasur may be due to local quality of soil. Chloride content is graphically represented in Fig No.9

5. **Alkalinity:**In the present study the alkalinity of water is found to be decreasing along with the downstream of the river. But at the last and second last site of our study, an increase in alkalinity is noted which could be accounted due to the local factors such as religious place, agricultural place etc. A graph of alkalinity is showed in Fig No. 8.
6. **Total Solid:**An attempt is made to determine the total solid content of Krishna River water. From the result it is clear that the total solid content decreases along with downstream of River except Narsingwadi. This decrease may be due to the adsorption of dissolved salts on earth surface. Furthermore this decrease in total solids is also due to the natural purification system of river such as the effect of sunlight and microbial activities going in the riverbed.
7. **Dissolved Oxygen:** The maximum concentration of oxygen that can be dissolved in water is function of temperature and therefore dissolved oxygen content of water may vary from place to place and time to time. In India average tropical temperature is 27^0C. Corresponding to this temperature, average dissolved oxygen saturation concentration is reported to be 8 ppm.[9]. This is the saturation limit at specific temperature, this represents 100% concentration.. The percentage of DO is suitable for survival of aquatic life. Percentage D.O. is graphically represented in Fig. No.15
8. **Dissolved Inorganic Ions:**n the present research work, metal ions have been analyzed by using flame photometry and atomic absorption spectroscopy[10-12]. These inorganic ions are found to be within the permissible limit for drinking water.

CONCLUSION

Water quality is a critical factor in well being of any area. The various parameters studied are within the permissible limits as per WHO and ICMR norms for drinking water (Table No. 2 &3). So the Krishna river water of studied area is imitable for drinking purposes in the studied period. The water is also suitable for culture of aquatic animals in river in the studied period.

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Table-1: Physico-Chemical Parameters and heavy metal contents of Krishna River in Western Maharashtra

Parameters	Sangli	Haripur	Ankali	Udgaon	Arjunwad	Ghalwad	Shirti	Hasur	Narsingwadi	Aurwad
Air Temp.	37.8	37	37.9	38	36.8	36.7	36.7	36.7	37.5	37.4
Water Temp.	31.5	30.8	31.7	31.8	30.3	30.5	30.6	30.5	31.3	31.4
pH	7.6	7.6	7.5	7.6	7.6	7.5	7.5	7.6	7.8	7.8
EC	265	373	194.5	320	230	270	392	323	1030	379
Total Hardness,ppm	45	45	35	41	30	32	36	35	65	60
Ca+2 (ppm)	27	25	20	24	18	19	20	25	40	40
Mg+2 (ppm)	18	20	15	17	12	13	16	10	25	30
Perment Hardnes,ppm	18	21	14	15	10	11	14	14	28	24
Chloride ,ppm	16.4	18.3	23	3.4	4	.12	6.8	36.9	9.2	7.6
Sulphate,ppm	48	63	58	66	60	67	71	64	43	51
Alkalinity,ppm	148	135	132	122	125	101	92	137	231	192
Total Solid ,ppm	420	470	50	80	110	100	160	110	190	210
Dissolved Solid ,ppm	320	310	30	60	75	60	105	70	150	160
Suspended solid,ppm	100	160	20	20	35	40	55	40	40	50
Dissolved oxygen,percent.	18%	21%	18%	19%	24.5 %	20%	24.3%	24%	23.5%	22%
Na ,ppm	20	22	21	21	22	21	20	28	44	38
K,ppm	2.1	1.9	2.3	2.3	2	1.8	1.8	1.9	1.9	2
Fe,ppm	0.20	0.21	0.24	0.4	0.22	0.09	0.06	0.32	0.97	0.8
Mn,ppm	0	0	0	0	0	0	0	0	0	0
Zn,ppm	22	21	24	25	23	22	32	27	22	20
Cu,ppm	0	0	0	0	0	0	0	0	0	0

Table-2: Comparison of water parameters with WHO standards in summer season

Parameters	WHO Standards	Average
Air Temperature	No guidelines	37.25
Water Temperature	No guidelines	31.04
pH	No guidelines	7.61

EC	2.50 μS / Cm	377.65
Total Hardness	No guidelines	42.4
Ca Hardness	No guidelines	25.8
Mg Hardness	No guidelines	17.6
Permanent Hardness	No guidelines	16.9
Chloride Content	250 ppm	12.572
Sulphate Content	500 ppm	59.1
Alkalinity		141.5
Total Solid	No guidelines	190
Total dissolved Solid	No guidelines	134
Suspended Solid	No guidelines	56
Percentage DO	No guidelines	0.2143
Na	200 ppm	25.7
K	--	2
Fa	No guidelines	0.351
Mn	0.5 ppm	0
Zn	3 ppm	23.8
Cu	2 ppm	0

Table-3: Comparative study of some observed parameters with ICMR standards in summer season.

Parameters	ICMR desirable limit	ICMR Max Limit	Average Observed Value
pH	6 - 8.5	No Relaxn.	7.61
Total hardnes,ppm	300	600	42.4
Ca Hardness,ppm	75	200	25.8
Mg Hardness,ppm	50		17.6
Chloride ,ppm	200	1000	12.5
Sulphate,ppm	200	400	59.1
Dissolved Solid ,ppm	500	1500-3000	134
Fe,ppm	0.1	1	0.35
Mn,ppm	0.1	0.5	0
Zn,ppm	0.1	5	23.8
Cu,ppm	0.05	1.5	0

Table – 4: Statistics of water parameters in summer season

Parameters	No of samples	MAX	MIN	Average
Air Temperature	10	38	36.7	37.25
Water Temperature	10	31.8	30.3	31.04
pH	10	7.8	7.5	7.61
EC	10	1030	194.5	377.65
Total hardnes,ppm	10	65	30	42.4
Ca Hardness,ppm	10	40	18	25.8
Mg Hardness,ppm	10	30	10	17.6
Perment Hardnes,ppm	10	28	10	16.9
Chloride ,ppm	10	36.9	0.12	12.572
Sulphate,ppm	10	71	43	59.1
Alkalinity,ppm	10	231	92	141.5
Total Solid ,ppm	10	470	50	190
Dissolved Solid ,ppm	10	320	30	134
Suspended solid,ppm	10	160	20	56
Dissolved oxygen,percent.	10	0.245	0.18	0.2143
Na ,ppm	10	44	20	25.7
K,ppm	10	2.3	1.8	2
Fe,ppm	10	0.97	0.06	0.351
Mn,ppm	10	0	0	0
Zn,ppm	10	32	20	23.8
Cu,ppm	10	0	0	0

Table-5: Statistics of water parameters in summer season

Parameters	No of samples	Variance	Std. Dev.	Poission	Ave. Dev.
Air Temperature	10	0.282777778	0.50447993	1.272E-07	0.47
Water Temperature	10	0.311555556	0.55817162	1.0945E-05	0.5
pH	10	0.012111111	0.11005049	0.85262487	0.076
EC	10	56858.11389	238.449395	0	133.61
Total hardnes,ppm	10	138.7111111	11.7775681	2.587E-09	9.08
Ca Hardness,ppm	10	64.84444444	8.05260482	0.00035491	5.92
Mg Hardness,ppm	10	37.15555556	6.09553571	0.03692045	4.52
Perment Hardnes,ppm	10	33.65555556	5.80134084	0.0514721	4.68
Chloride ,ppm	10	125.5691733	11.2057652	0.29023812	8.8624
Sulphate,ppm	10	82.32222222	9.07315944	0	7.28

Alkalinity,ppm	10	1722.055556	41.4976572	0	29.3
Total Solid ,ppm	10	20577.77778	143.449565	0	106
Dissolved Solid ,ppm	10	10743.33333	103.650052	0	80.8
Suspended solid,ppm	10	1843.333333	42.934058	3.996E-14	29.6
Dissolved oxygen,percent.	10	0.000672678	0.02593603	1	0.0223
Na ,ppm	10	72.23333333	8.49901955	0.00037808	6.58
K,ppm	10	0.033333333	0.18257419	0.99999169	0.14
Fe,ppm	10	0.090343333	0.30057168	1	0.2234
Mn,ppm	10	0	0	1	0
Zn,ppm	10	12.4	3.52136337	0.00122491	2.56
Cu,ppm	10	0	0	1	0

Table-6: Figure Captions

Figure Number	**Change in Parameter**
Fig. 1	Change in Air Temperature at various locations
Fig. 2	Change in Water Temperature at various locations
Fig. 3	Change in pH at various locations
Fig. 4	Change in EC at various locations
Fig. 5	Change in Total Hardness at various locations
Fig. 6	Change in Ca Hardness at various locations
Fig. 7	Change in Mg Hardness at various locations
Fig. 8	Change in Permanent Hardness
Fig.9	Change in Chloride content at various locations
Fig 10	Change in Sulphate content at various locations
Fig 11	Change in Alkalinity content at various locations
Fig 12	Change in Total Solid content at various locations
Fig 13	Change in TDS content at various locations
Fig 14	Change in TSS content at various locations
Fig 15	Change in Percentage DO at various locations
Fig16	Change in Na content at various locations
Fig 17	Change in K content at various locations
Fig 18	Change in Fe content at various locations
Fig 19	Change in Zn content at various locations

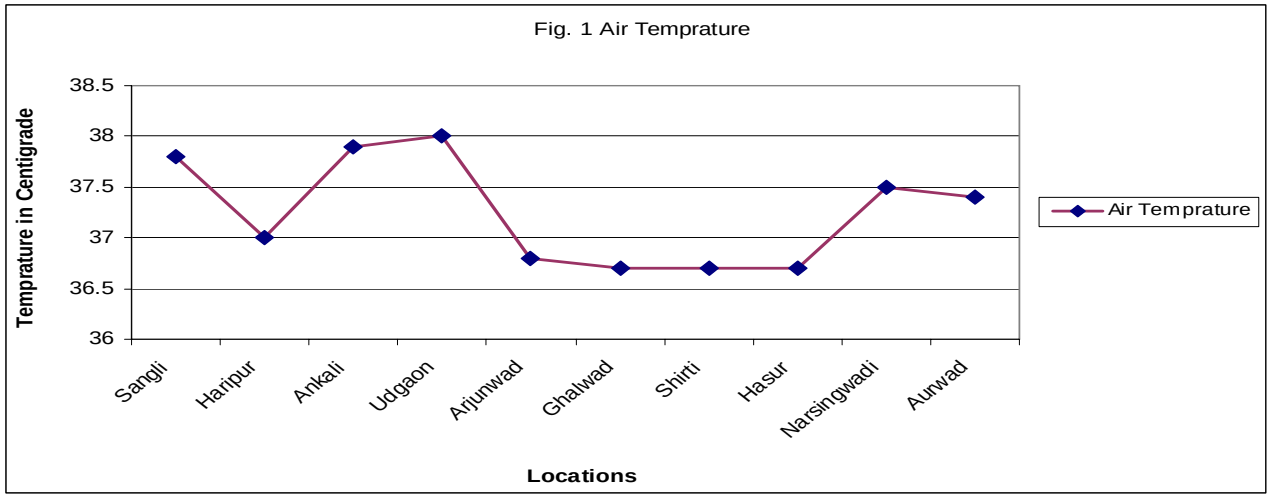


Fig. 1 Air Temprature
Temprature in Centigrade
38.5
38
37.5
37
36.5
36
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations
Air Temprature

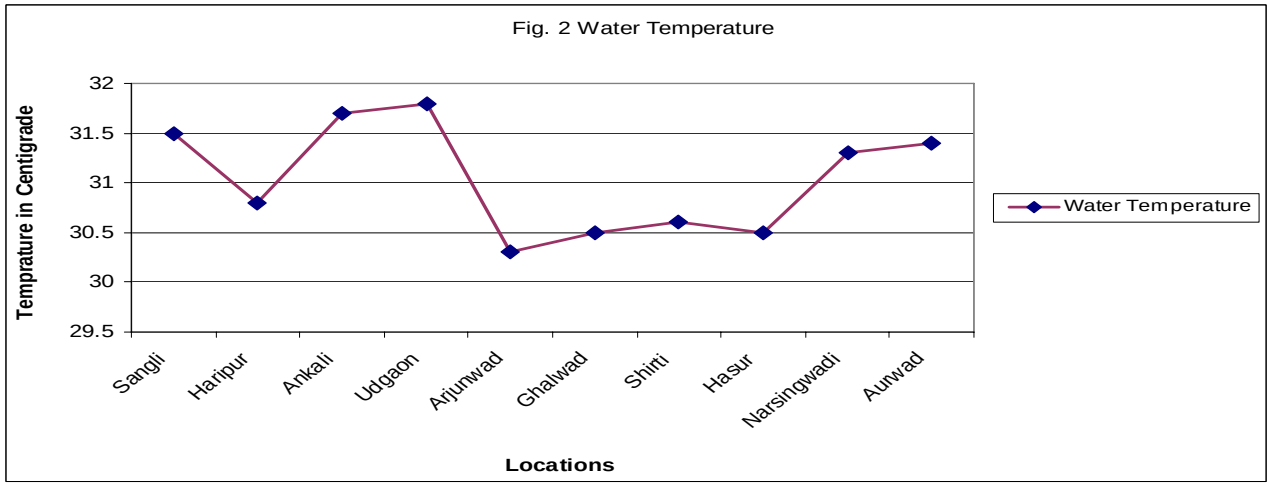


Fig. 2 Water Temperature
Temprature in Centigrade
32
31.5
31
30.5
30
29.5
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations
Water Temperature

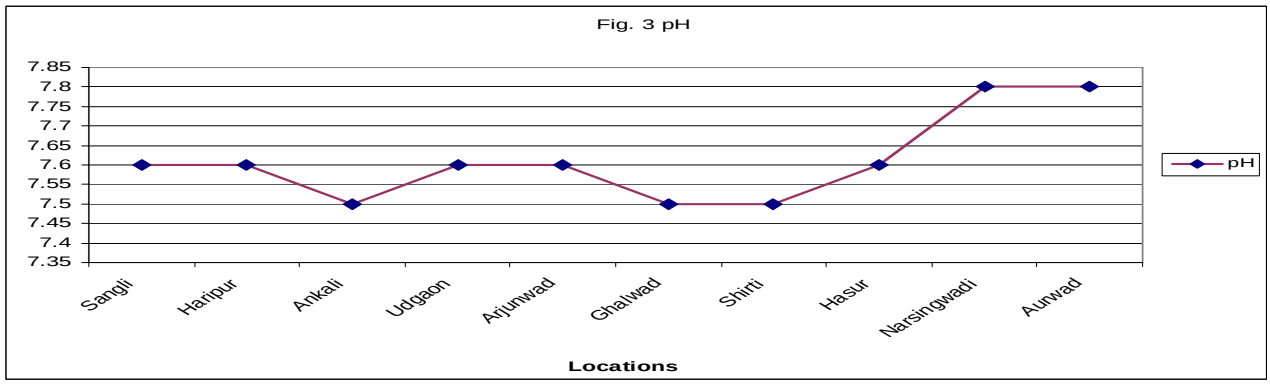


Fig. 3 pH
7.85
7.8
7.75
7.7
7.65
7.6
7.55
7.5
7.45
7.4
7.35
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations
pH

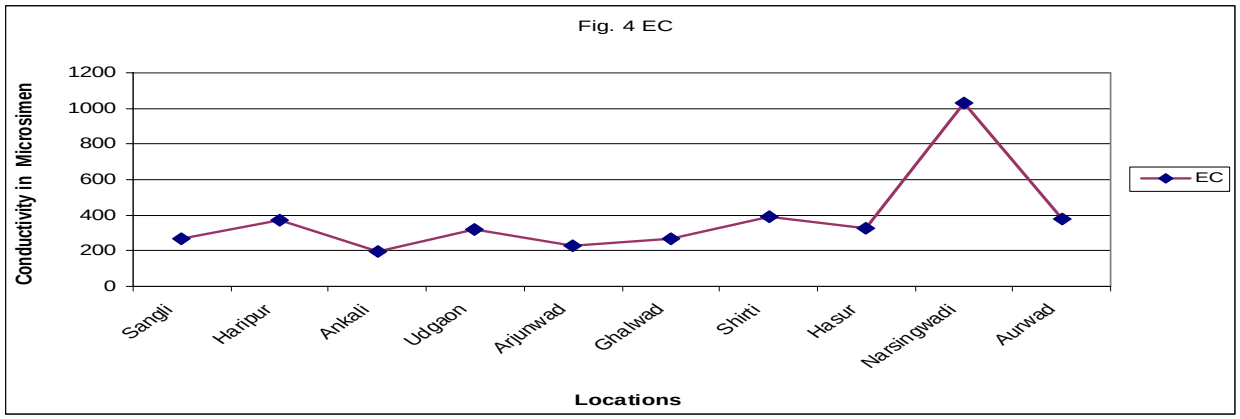


Fig. 4 EC
Conductivity in Microsimen
1200
1000
800
600
400
200
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations
EC

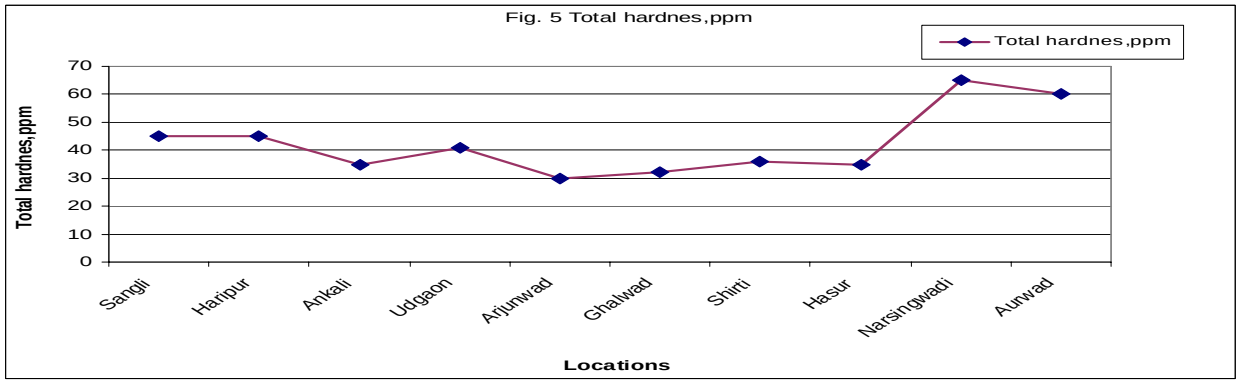


Fig. 5 Total hardnes,ppm
Total hardnes,ppm
70
60
50
40
30
20
10
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations
Total hardnes,ppm

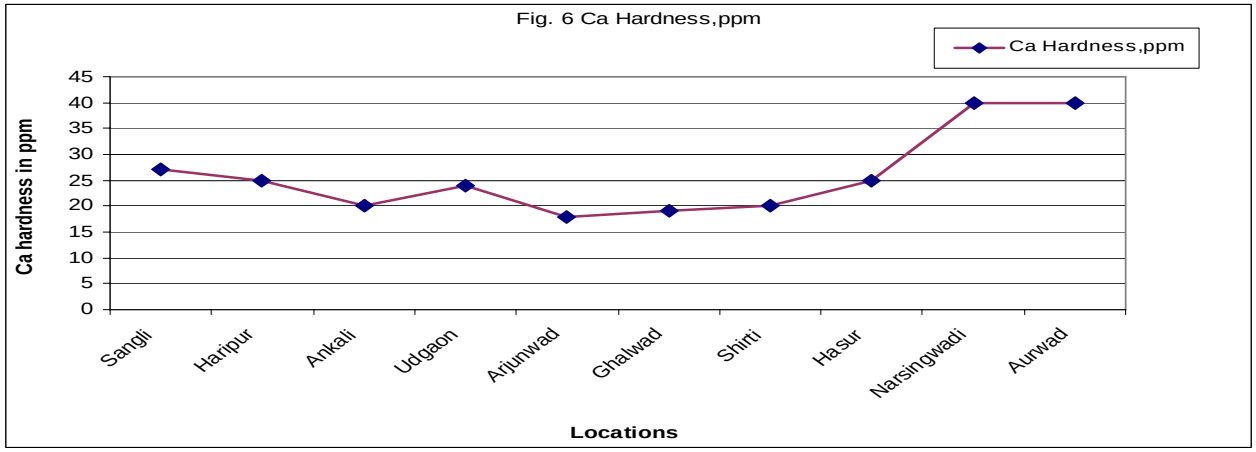


Fig. 6 Ca Hardness,ppm
Ca hardness in ppm
45
40
35
30
25
20
15
10
5
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations
Ca Hardness,ppm

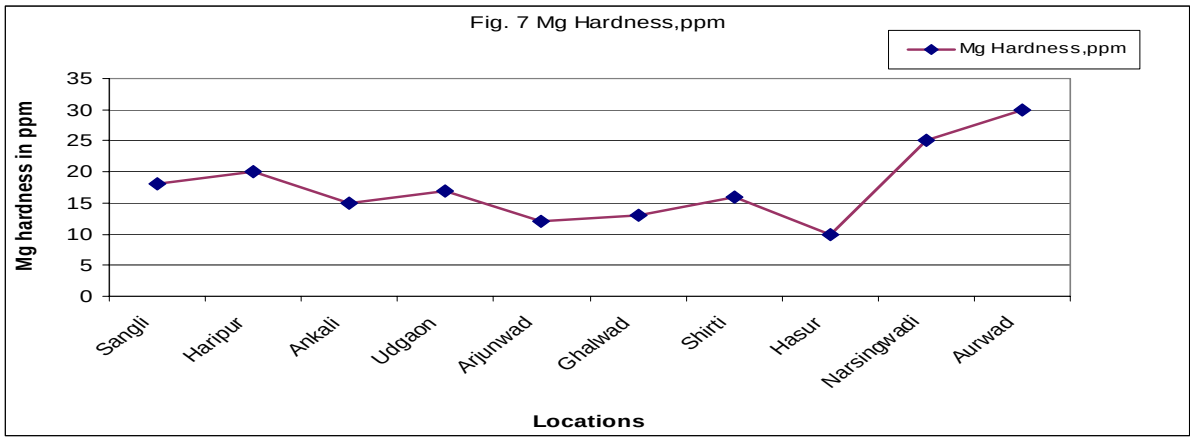


Fig. 7 Mg Hardness,ppm
Mg Hardness,ppm
Mg hardness in ppm
35
30
25
20
15
10
5
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

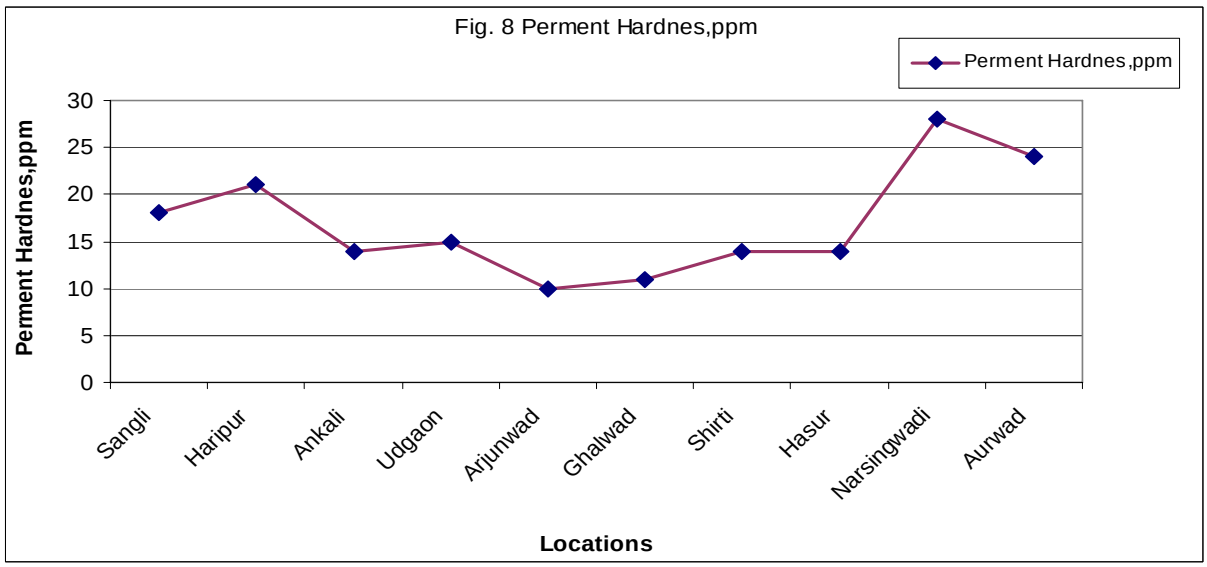


Fig. 8 Perment Hardnes,ppm
Perment Hardnes,ppm
Perment Hardnes,ppm
30
25
20
15
10
5
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

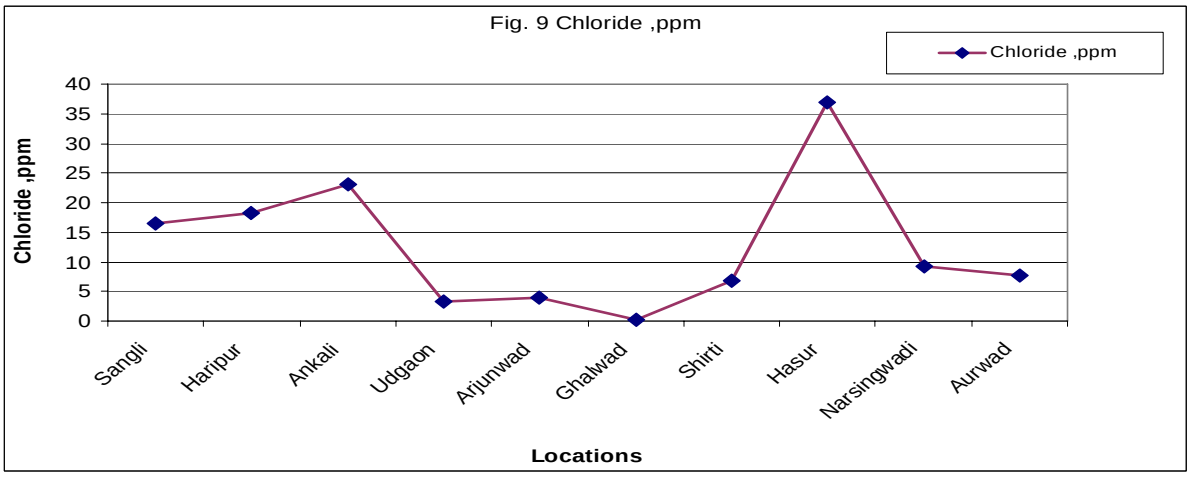


Fig. 9 Chloride ,ppm
Chloride ,ppm
Chloride ,ppm
40
35
30
25
20
15
10
5
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

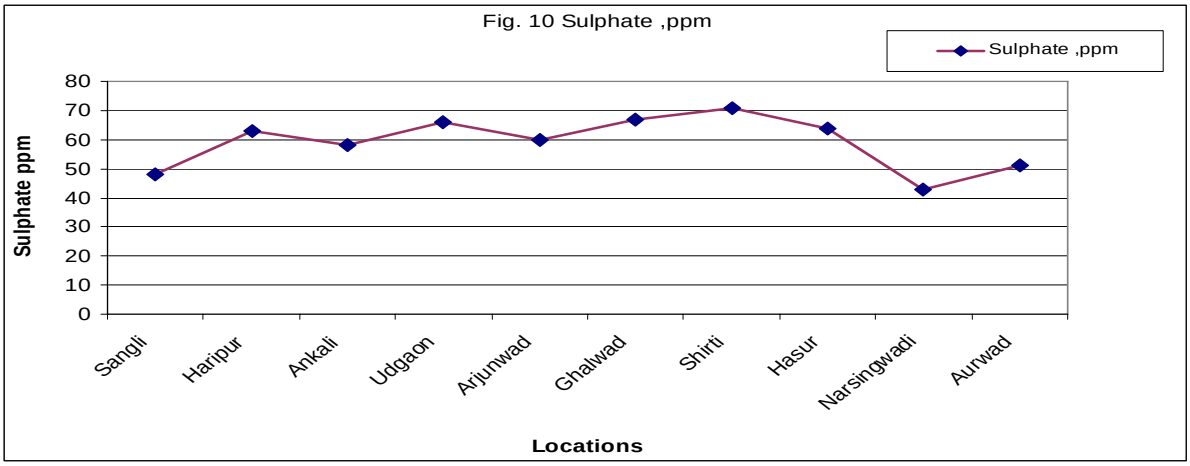


Fig. 10 Sulphate ,ppm
Sulphate ,ppm
Sulphate ppm
80
70
60
50
40
30
20
10
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

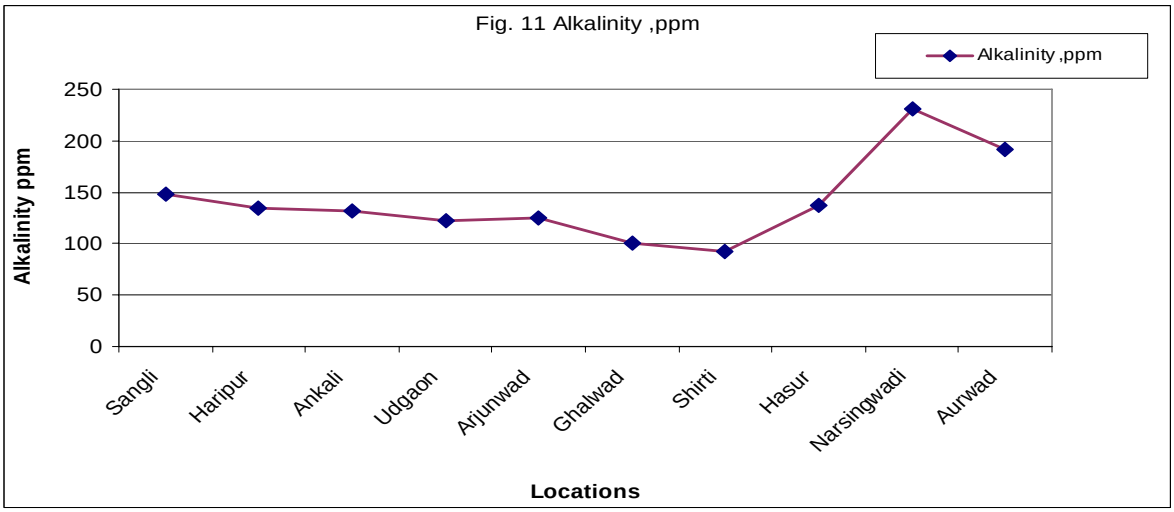


Fig. 11 Alkalinity ,ppm
Alkalinity ,ppm
Alkalinity ppm
250
200
150
100
50
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

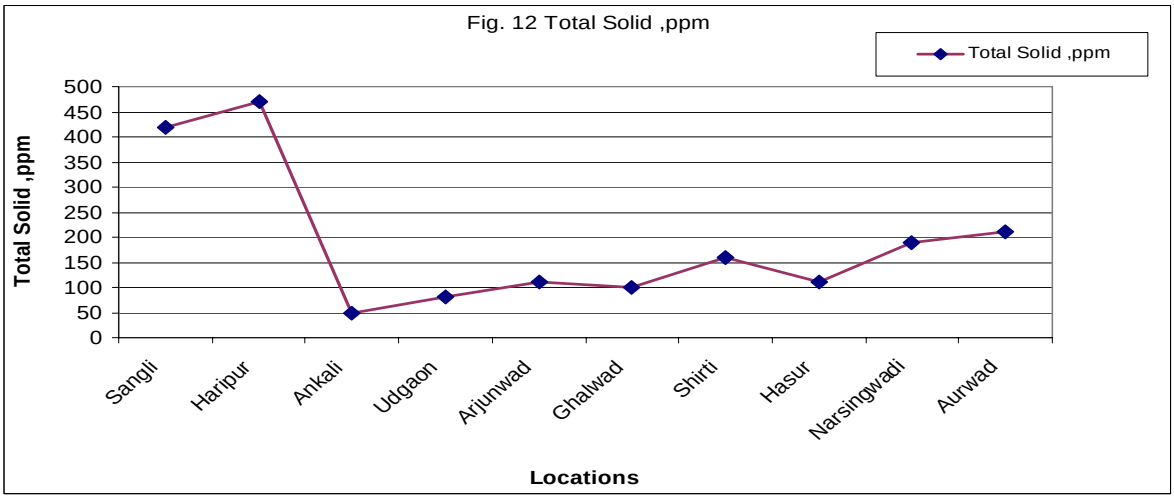


Fig. 12 Total Solid ,ppm
Total Solid ,ppm
Total Solid ,ppm
500
450
400
350
300
250
200
150
100
50
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

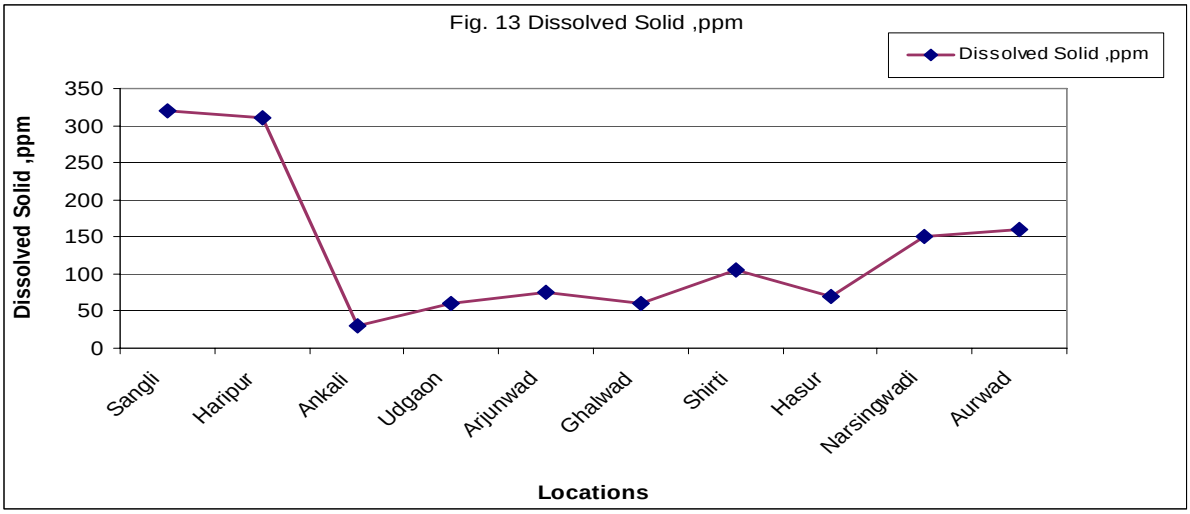


Fig. 13 Dissolved Solid ,ppm
Dissolved Solid ,ppm
Dissolved Solid ,ppm
350
300
250
200
150
100
50
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

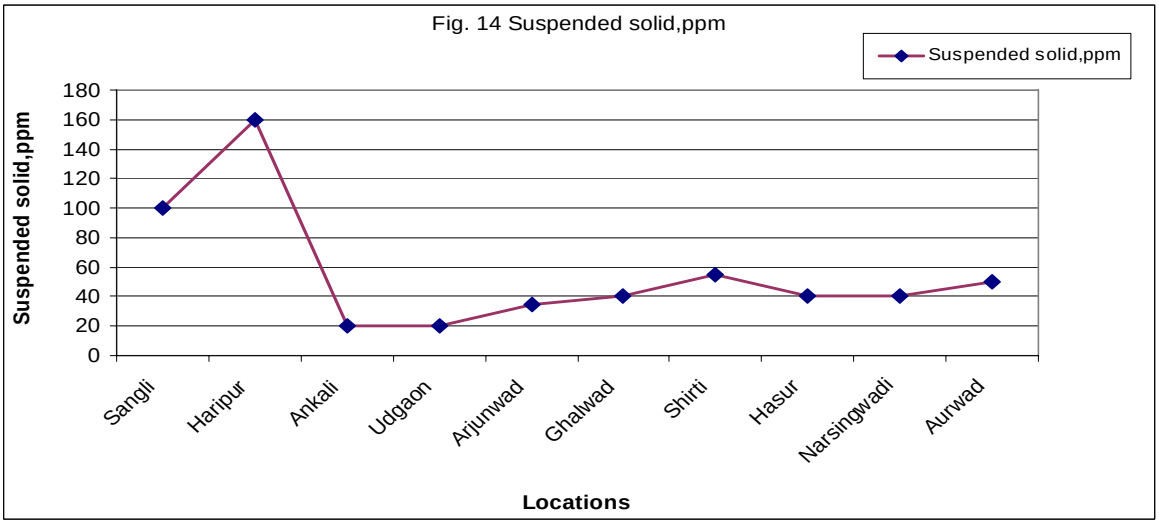


Fig. 14 Suspended solid,ppm
Suspended solid,ppm
Suspended solid,ppm
180
160
140
120
100
80
60
40
20
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

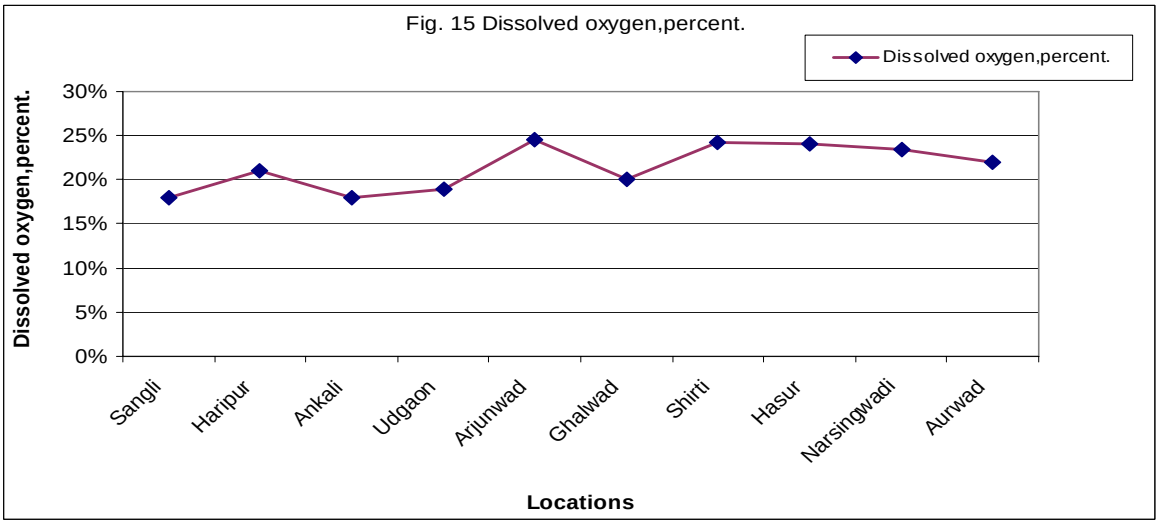


Fig. 15 Dissolved oxygen,percent.
Dissolved oxygen,percent.
Dissolved oxygen,percent.
30%
25%
20%
15%
10%
5%
0%
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

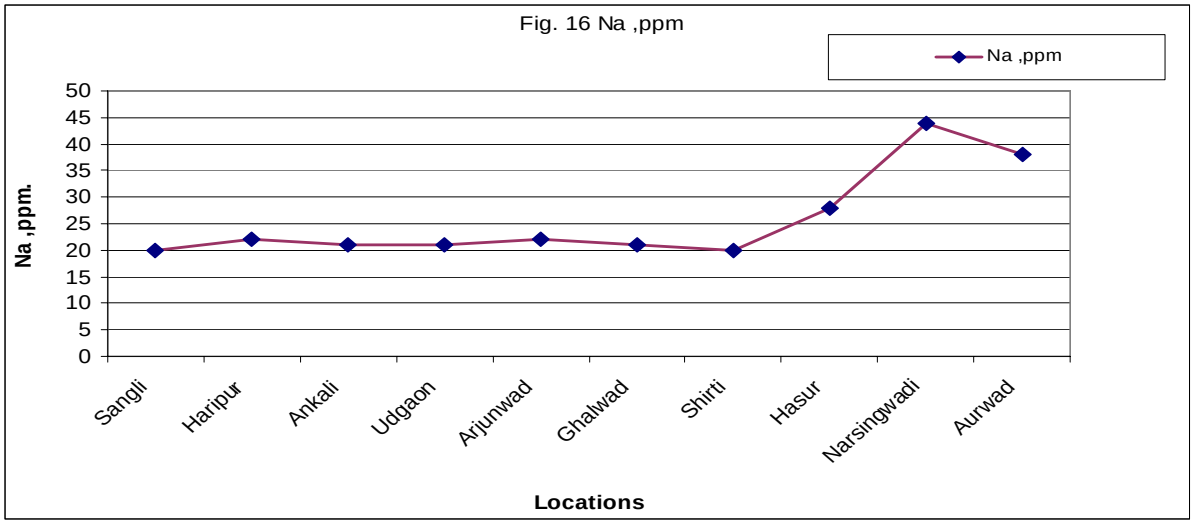


Fig. 16 Na ,ppm
Na ,ppm
Na ,ppm.
50
45
40
35
30
25
20
15
10
5
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

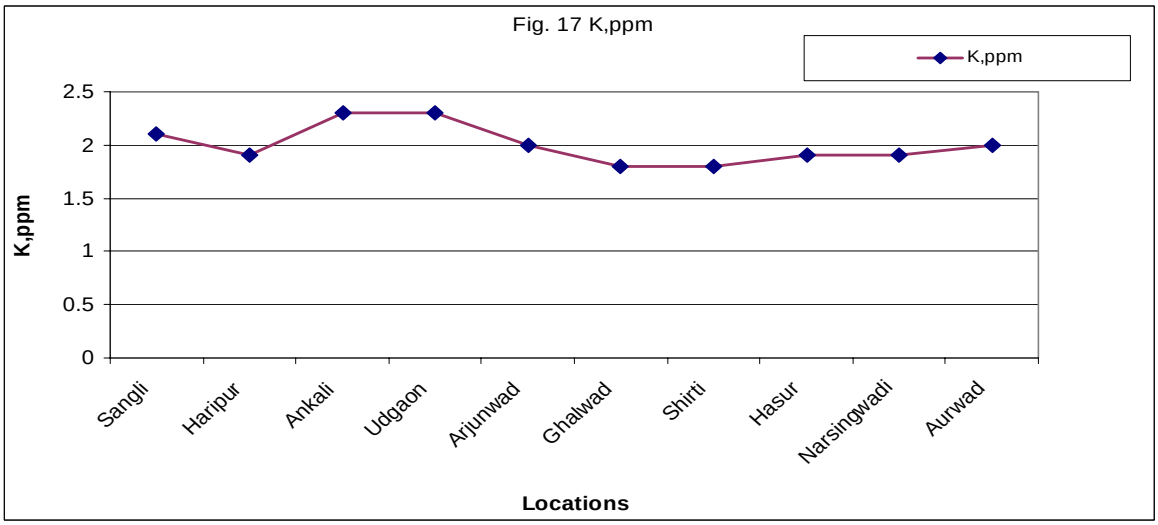


Fig. 17 K,ppm
K,ppm
K,ppm
2.5
2
1.5
1
0.5
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations

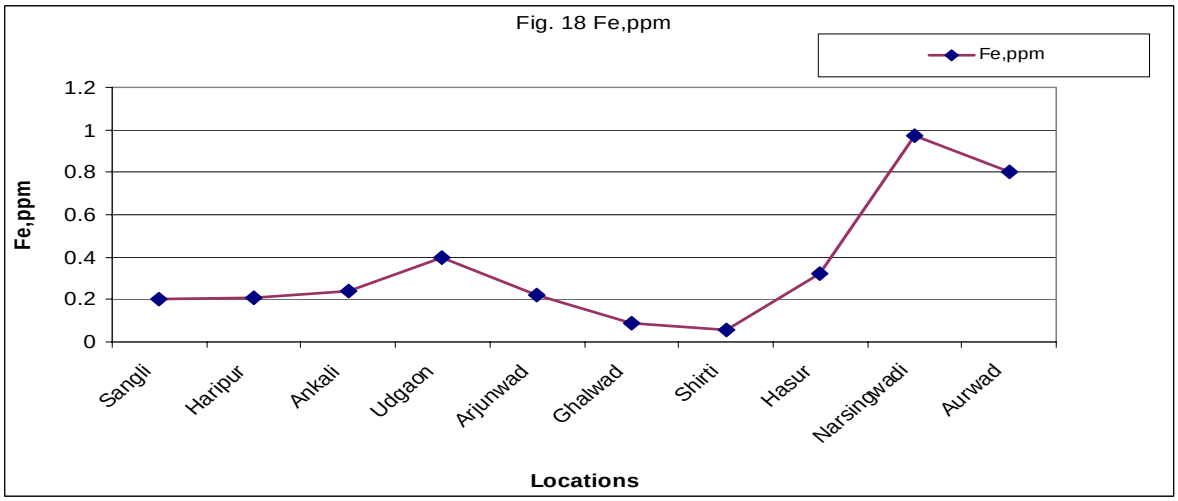
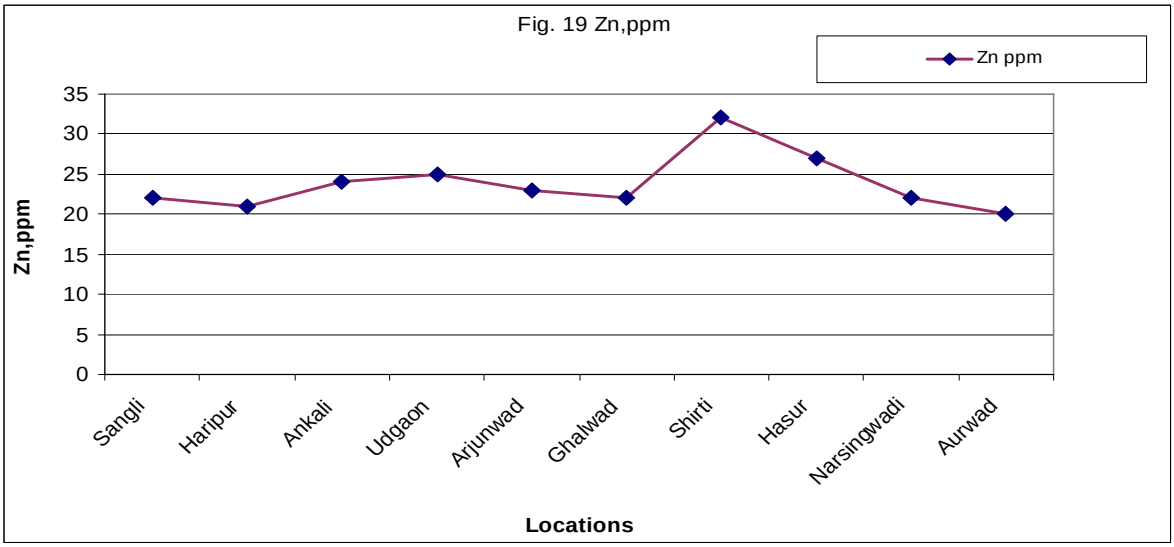


Fig. 18 Fe,ppm
Fe,ppm
Fe,ppm
1.2
1
0.8
0.6
0.4
0.2
0
Sangli
Haripur
Ankali
Udgaon
Arjunwad
Ghalwad
Shirti
Hasur
Narsingwadi
Aurwad
Locations



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