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Assessment of water quality of fresh water lakes of different regions in Maharashtra state, India

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Abstract
The present study was carried out to assess the physico-chemical properties of a large set of lakes of Maharashtra state, India. Eighteen lake water samples were collected from different districts of Maharashtra state, India. Water samples such as temperature, pH, total solids, dissolved oxygen, alkalinity, total hardness, phosphate, sulphate, calcium and magnesium determined using standard methods. Lowest values in most of the water quality parameters were found in Kirtanwadi lake, Ratnagiri district. That may be indication due to low pollution level in Kirtanwadi lake, Ratnagiri district. High values of the water quality parameters were found in some lakes such as Sambhaji lake, Solapur district, Ramala lake, Chandrapur district, Naik lake, Nagpur etc. Henceforth, these results might increase the chance of damage of the aquatic eco-system.
Keywords: Water quality, Lakes, Lakes in Maharashtra state, India

1Introduction

Most human practices involve in use of water in one way or other ways. Industrial and agricultural progress of the country largely depends on its water resources, particularly lakes, rivers and oceans (Desai and Shrivastava, 2004). However, lakes are valuable assets of a nation that are continuously utilized for the various needs of the society such as drinking, irrigation, industrial usage and recreation. In the last five decades, water quality of lake is progressive degraded due to three major factors such as domestic sewage, industries effluents and agricultural runoff. The impact of domestic sewage and industrial effluents are more serious in the case of lakes in the urban areas (Cairns and Dickson, 1971). Lake ecosystems contain fragile habitats and they are susceptible to damage even with only a small change in the composition of biotic and abiotic factors. The overall status or health of aquatic ecosystems is influenced by the interaction of its entire physical, chemical and biological components that make up its ecosystem. Lake ecosystems are endangered due to poor water holding capacity, excessive withdrawal and pollution due to sewage, industrial effluents, leached fertilizers, eutrophication and insecticides. Monitoring of water characteristics, sediment properties and algal biodiversity play an important role in assessment of aquatic system. The physico-chemical characteristics of water bodies are not constant and fluctuate with seasonal variation as well as degree of pollution (Forstner and Witlmann, 1979).

The aim of this work was to study the water quality from different lakes of Maharashtra, India that provided better understanding of lake ecology.

2 Material and Methods

2.1 Chemicals and glasswares

All chemicals purchased from E. Merck, Sigma Aldrich, Fisher Scientific, Qualigens, Hi-Media were of the highest analytical grade. All glassware and instrumentation used in this study. Glasswares were pre-washed with chromic acid and rinsed with deionized water according to the method of Tessier et al. (1979). All reagents were prepared using water from Millipore Elix 10 integrated with Milli-Q synthesis water purification unit.

2.2 Sampling

Water samples were taken in sterilized sampling bottles, below 10 to 20 cm of the surface from study sites. Water samples were collected in three replicates. All lakes were sampled and mostly from 1 meter's depth, covering physical, chemical parameters.

2.3 Sampling lakes

Study area covers a large geographical area, including a large set of lakes of Maharashtra state, India. Figure 2.1 shows a map of districts of Maharashtra state where study lakes are situated and Table 2.1 shows latitudes and longitudes of study lakes, districts of lakes in Maharashtra state, India.

2.4 Methods of water quality analysis of water samples

Water samples were subjected to chemical analysis with the prescribed procedures of dissolved oxygen (DO), pH, total hardness, sulphate, phosphate, alkanity, calcium and magnesium. The temperature of the water samples measured using centigrade thermometer on the lake sites.. DO was estimated on the site by Wrinkler method and total hardness, Ca and Mg estimated by using EDTA complexometric titration and sulphate was determined by barium chloride and measured with spectrophotometer (APHA 2005).

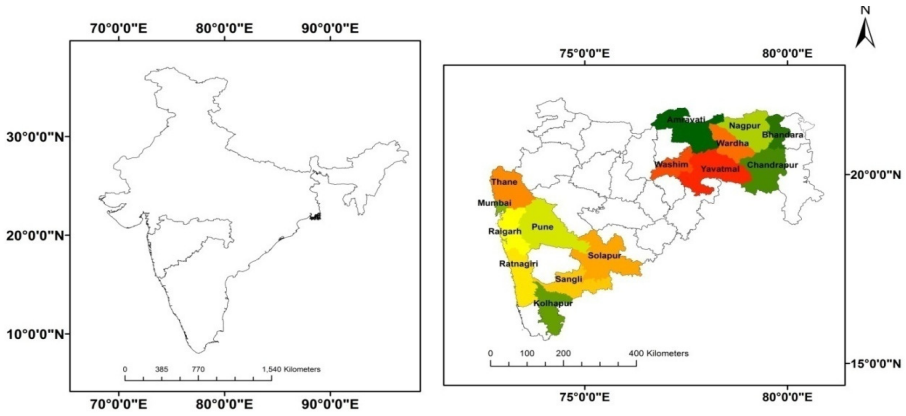

Figure 2.1: Map shows various districts of Maharashtra state where study lakes are situated

Table 2.1: Locations of study lakes in Maharashtra state, India.

District	Name of lake	Lakes code	Latitude	Longitude
Mumbai	Bandra lake	L1	72.83764N	19.05679E
Thane	Upavan lake	L2	72.95583 N	19.22139E
Ratnagiri	Kirtanwadi lake	L3	73.20861 N	17.47694E
Raigad	Vishrale lake	L4	73.11472 N	18.98278E
Pune	Pashan lake	L5	73.78572 N	18.53375E
Sangli	Morna lake	L6	74.09889 N	16.99944E
Solapur	Sambhaji lake	L7	75.90389 N	17.64778E
Kolhapur	Kalamba lake	L8	74.21250 N	16.65444E
Washim	Rishi lake	L9	77.48333 N	20.48333E
Yavatmal	Arunavati lake	L10	77.78333 N	20.11944E
Wardha	Mahakali lake	L11	78.45306 N	20.95500E
Amravati	Triveni lake	L12	77.89444 N	21.34028E
Chandrapur	Ramala lake	L13	79.30306 N	19.95361E
Bhandara	Nav lake	L14	79.65694 N	21.16083E
Nagpur	Ambazari lake	L15	78.27194 N	20.58917E
Nagpur	Futala lake	L16	79.04222 N	21.15306E
Nagpur	Gandhisagar lake	L17	79.09972 N	21.14556E
Nagpur	Naik lake	L18	79.11250 N	21.16083E

3 Results and discussion

A number of water quality parameters were considered in this study that included temperature, pH, Total solids, alkalinity, DO, hardness, phosphate, sulphate, calcium and magnesium for different lakes in Maharashtra state.

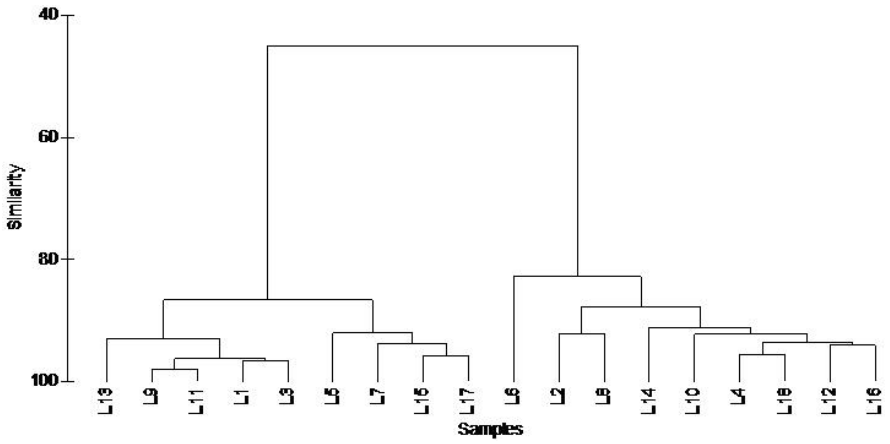

Figure 3.1: Dendrogram for water quality of water samples in lakes of different districtsof Maharashtra, India, using Bray–Curtis similarity index

A Bray-Curtis cluster analysis performed using water quality data to evaluate similarities between the eighteen lakes of different districts of Maharashtra, India. Dendogram assessed grouping of lakes was meaningful from ecological perspective. The analysis separated the lakes into two groups of lakes, were shown in the dendrogram in figure 3.1.

Principle cluster analysis performed using water quality data revealed 60 % Bray–Curtis similarity. Green, blue and cyan colour lines represent the principal clusters identified at 40, 60 and 90% Bray Curtis similarities respectively. Blue colour dashed line principle clusters shown two groups of clusters. Groups I comprised L2 (Upavan lake), L4 (Vishrale lake), L6 (Morna lake), L8 (Kalamba lake), L10 (Arunavati lake), L12 (Triveni lake), L14 (Nav lake), L16 (Futala lake) and L18 (Naik lake). Groups II comprised L1 (Bandra lake), L3 (Kirtanwadi lake), L5 (Pashan lake), L7 (Sambhaji lake), L9 (Rishi lake), L11 (Mahakali lake), L13 (Ramala lake), L15 (Ambazari lake) and L17 (Gandhisagar lake), shown in Figure 3.2.

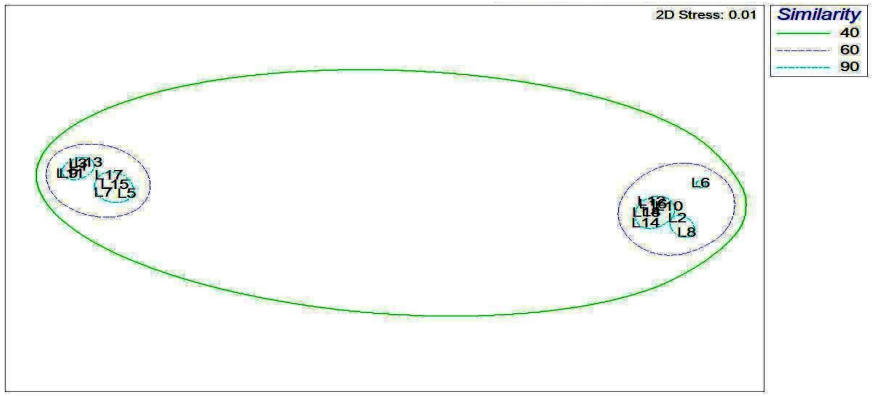

Figure 3.2: Water quality parameters in Lakes of different districts of Maharashtra, India, coupled to a cluster analysis. Green, blue and cyan colour lines represent the principal clusters identified at 40, 60 and 90% Bray Curtis similarity respectively.

Water quality parameters were contoured for the study that included temperature, pH, Total solids, alkalinity, DO, hardness, phosphate, sulphate, calcium and magnesium. The contour maps are also useful to show the isograms of equally chemical concentrations. These isograms help to find the regions of low and high chemical concentrations of water in lakes *of different districts of Maharashtra, India.* Temperature in the study areas showed lowest (24^0C) in Sambhaji lake and highest (31^0C) inBandra lake, Ramala lake, Nav lake and Naik lake.

pH is an important factor that determines the suitability of water for various purposes, including toxicity to animals and plants. pH of natural waters is governed by the carbonate–bicarbonate carbon dioxide equilibrium. Slightly alkaline pH is preferable in waters, as heavy metals are removed as carbonate or bicarbonate precipitates. Such water is not as toxic to aquatic life as they are present mostly in the unavailable form. The pH in the study areas showed lowest at Kirtanwadi lake, Ratnagiri lake (7.24±0.11) and highest at Sambhaji lake, Solapur district (8.91 ±0.34).

The alkalinity in the study areas showed lowest (108±7 mg/L) at Triveni lake, Amravati district and highest (198±14 mg/L) at Ramala lake, Chandrapur. Lowest alkalinity of 108±7 mg/L at Triveni lake, Amravati district shown in purple colour in the figure 3.3. Highest alkalinity of 198±14 mg/L at Ramala lake, Chandrapur district shown in white colour in the figure 3.3.

Generally, variation in Dissolved oxygen (DO) is basically governed by photosynthesis, respiration, mineralization and decomposition activities in water. The imbalance between relatively high rates of O_2 consumption and low rates of O_2 resupply causes DO content to drop to levels that are low enough to adversely affect oxygen-requiring animal and plant life. DO in the study areas showed lowest (2.8±0.3 mg/L) at Bandra lake, Mumbai district and highest (7.8±0.67 mg/L) at Kirtanwadi lake, Ratnagiri district. It is highly suitable for fishery. Lowest DO of 2.8±0.3 mg/L at Bandra lake, Mumbai district shown in sky blue colour in the figure 3.4 Highest DO of 7.8±0.67 mg/L at Kirtanwadi lake, Ratnagiri district shown in white colour in the

figure 3.4.

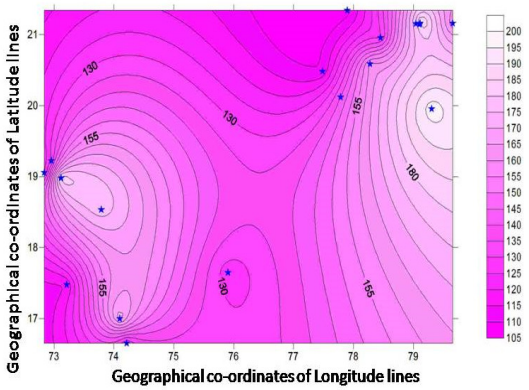

Figure 3.3: Surfer Contour/Post Map showing alkalinities of lakes of different districts of Maharashtra, India

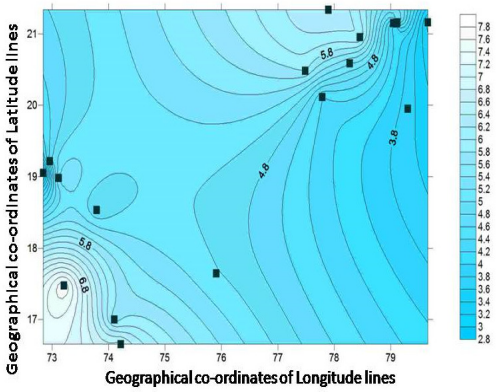

Figure 3.4: Surfer Contour/Post Map showing DO of lakes of different districts of Maharashtra, India

The common source of solids in natural waters are rain and wind erosion of soil surfaces along with municipal and industrial waste waters originated from domestic wastes, road run off and industrial process. Total solids in the study areas showed lowest (900±40 mg/L) at Kirtanwadi lake, Ratnagiri district and highest (3120±190 mg/L) at Ramala lake, Chandrapur district. Lowest total solids of 900±40 mg/L at Kirtanwadi lake, Ratnagiri district shown in yellow colour in the figure 3.5. Highest total solids of 3120±190 mg/L at Ramala lake, Chandrapur district shown in white colour in the figure 3.5.

Natural hardness of water depends upon the geological nature of the drainage basin and mineral levels found in natural water. The hardness of water is not a pollution parameter but indicates water quality. In the present study, it showed significant temporal and spatial fluctuation, total hardness as $CaCO_3$ ranged between 101±12 mg/L (Kalamba lake, Kolhapur district) to 295±13 mg/L (Ramala lake, Chandrapur district). Lowest hardness of 101±12 mg/L at Kalamba lake, Kolhapur district shown in cyan colour in the figure 3.6. Highest total solids of 295±13 mg/L at Ramala lake, Chandrapur district shown in faint cyan colour in the figure 3.6. The total hardness of all lakes were found below the BIS recommended limit of total hardness for drinking water that is reported to be 300 mg/L.

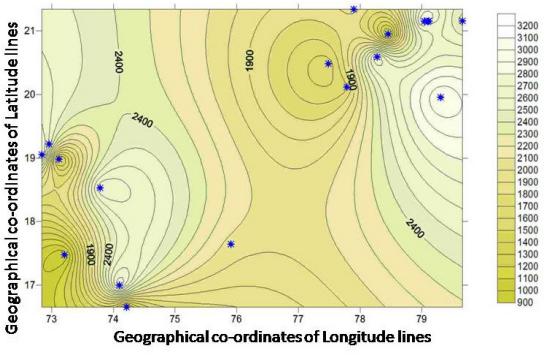

Figure 3.5: Surfer Contour/Post Map showing total solids in lakes of different districts of Maharashtra, India

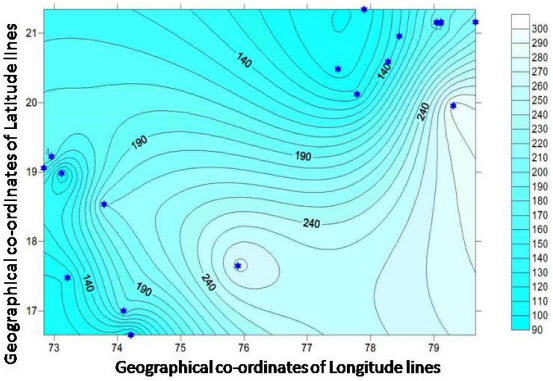

Figure 3.6: Surfer Contour/Post Map showing total hardness of lakes of different districts of Maharashtra

In the present study, it shows significant fluctuation of phosphate ranged between 0.061±0.009 mg/L (Kirtanwadi lake, Ratnagiri district) to 0.87±0.076 mg/L (Ramala lake, Chandrapur district). Lowest phosphate of 0.061±0.009 mg/L at Kirtanwadi lake, Ratnagiri district shown in green colour in the figure 3.7. Highest phosphate of 0.87±0.076 mg/L at Ramala lake, Chandrapur district shown in white colour in the figure 3.7. The occurrence of sulphate ions is in the form of dissolved sodium sulphate, calcium sulphate and magnesium sulphate practically at alkaline condition was common. The main source of sulphate ions was probably from industrial effluent, discharged unit and lake discharges. In the present study, it shows significant fluctuation of sulphate ranged between 14±0.63 mg/L (Arunavati lake, Yavatmal district) to 55±0.47 mg/L (Kalamba lake, Kolhapur district). Lowest sulphate of 14±0.63 mg/L at Arunavati lake, Yavatmal district shown in green colour in the figure 3.8. Highest sulphate of 55±0.47 mg/L at Kalamba lake, Kolhapur district shown in white colour in the figure 3.8.

Table 2.2: Water quality parameters of water samples in lakes of different districts of Maharashtra, India

Lakes code	Temp.	pH	Alkalinity	DO	Total solids	Hardness	Phosphate	Sulphate	Ca	Mg
L1	31	7.91±0.5	124±2	2.8±0.3	2850±110	166±12	0.171±0.032	29±0.98	48±2.30	8±0.76
L2	28	7.40±0.89	131±5	4.71±0.8	2590±170	180±19	0.158±0.078	42±0.47	61±1.60	13±0.32
L3	27	7.24±0.11	115±8	7.8±0.67	900±40	112±14	0.061±0.098	18±0.83	39±1.47	11±0.66
L4	30	7.50±1.3	183±3	5.3±0.43	1280±80	106±09	0.193±0.023	21±0.35	76±2.89	13±0.38
L5	28	8.07±0.54	178±9	4.8±0.5	2810±130	210±06	0.43±0.044	27±0.58	73±1.41	19±0.63
L6	26	7.76±1.2	173±11	5.7±0.3	2930±180	176±08	0.083±0.073	37±0.43	69±1.57	17±0.42
L7	24	8.91±0.34	127±6	5.02±0.2	2060±210	274±10	0.182±0.036	32±0.71	50±2.42	11±0.91
L8	27	7.75±0.88	125±17	6.7±0.5	1200±150	101±12	0.19±0.048	55±0.47	53±1.06	09±0.37
L9	26	7.90±1.5	111±10	5.82±0.8	1540±160	104±15	0.26±0.039	53±0.82	48±1.53	18±0.45
L10	28	7.50±0.91	140±11	4.4±0.31	1670±230	123±12	0.11±0.081	14±0.63	63±2.44	15±0.71
L11	27	7.50±0.66	129±5	6.2±0.44	1100±160	141±07	0.14±0.063	31±0.59	51±1.06	14±1.43
L12	27	7.64±0.41	108±7	6.41±0.72	1940±170	102±17	0.39±0.049	29±0.32	45±0.99	13±0.53
L13	31	8.03±0.59	198±14	3.7±0.29	3120±190	295±13	0.870.076	46±0.84	85±2.87	15±1.42
L14	31	7.90±1.26	156±10	3.1±0.51	2340±140	204±10	0.43±0.95	30±0.93	82±3.24	23±0.22
L15	30	8.11±0.33	161±8	5.21±0.79	2840±250	137±21	0.15±0.071	26±0.48	40±0.48	19±0.55
L16	27	8.20±0.98	179±3	4.29±0.86	2980±270	187±19	0.262±0.085	34±0.75	44±1.33	07±1.74
L17	29	8.39±0.19	183±2	4.09±0.33	2530±290	168±05	0.311±0.046	48±0.40	54±1.90	09±0.73
L18	31	8.90±0.49	194±5	5.29±0.49	2870±260	187±16	0.609±0.037	54±0.65	79±1.36	12±0.49

In the present study, it shows significant fluctuation of Calcium ranged between 39±1.47 mg/L (Kirtanwadi lake, Ratnagiri district) to 85±2.87 mg/L (Ramala lake, Chandrapur district). Lowest calcium of 39±1.47 mg/L at Kirtanwadi lake, Ratnagiri district shown in purple colour in the figure 3.9. Highest calcium of 85±2.87 mg/L at Ramala lake, Chandrapur district shown in white colour in the figure 3.9.

In the present study, it shows significant fluctuation of Magnesium ranged between 7±1.74 mg/L (Futala lake, Nagpur district) to 23±0.22 mg/L (Nav lake, Bhandara district). Lowest Magnesium of 7±1.74 mg/L at Futala lake, Nagpur district shown in pink colour in the figure 3.10. Highest Magnesium of 23±0.22 mg/L at Nav lake, Bhandara district shown in white colour in the figure 3.10.

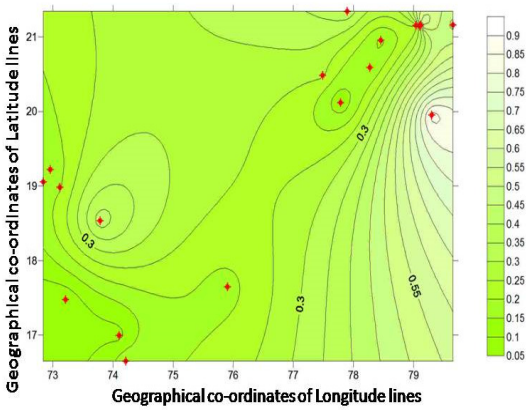

Figure 3.7: Surfer Contour/ Post Map showing phosphate of lakes of different districts of Maharashtra, India

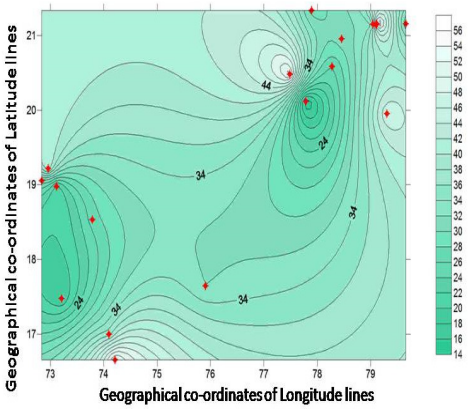

Figure 3.8: Surfer Contour/ Post Map showing sulphate of lakes of different districts of Maharashtra, India

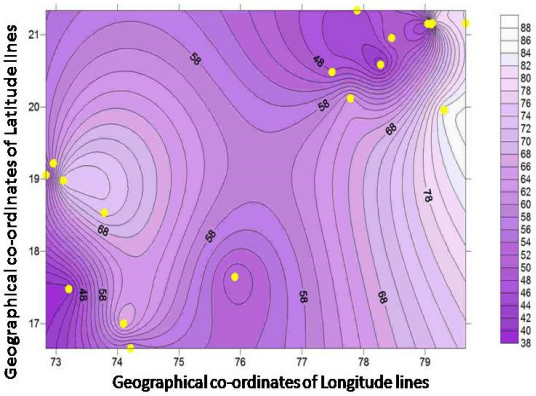

Figure 3.9: Surfer Contour/ Post Map showing calcium of lakes of different districts of Maharashtra, India

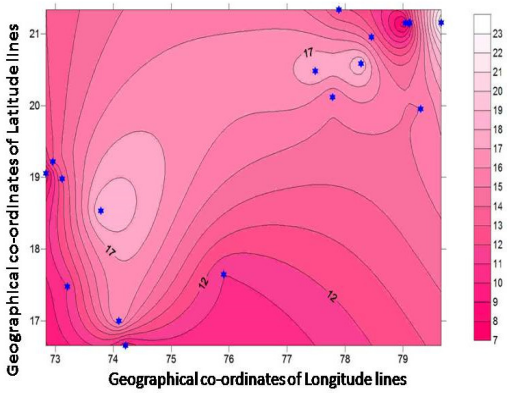

Figure 3.10: Surfer Contour/Post Map showing magnesium of lakes of different districts of Maharashtra, India

Conclusion

Study area covers a large geographical area, including a large set of lakes of Maharashtra state, India. Eighteen lake water samples were collected from different districts of Maharashtra state, India. Water samples such as temperature, pH, total solids, dissolved oxygen, alkalinity, total hardness, phosphate, sulphate, heavy metals of water i.e. calcium, magnesium, lead, iron, cadmium, copper and manganese were determined using standard methods. Lowest values in most of the water quality parameters were found in Kirtanwadi lake, Ratnagiri district. That may be indication due to low pollution level in Kirtanwadi lake, Ratnagiri district. High values of the water quality parameters were found in some lakes such as Sambhaji lake, Solapur district, Ramala lake, Chandrapur district, Naik lake, Nagpur etc. That may be indication due to high pollution level in lakes.

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