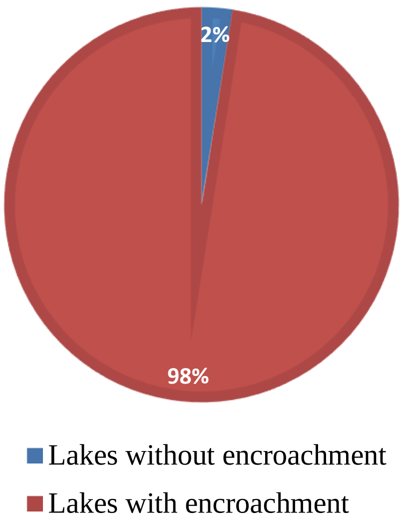
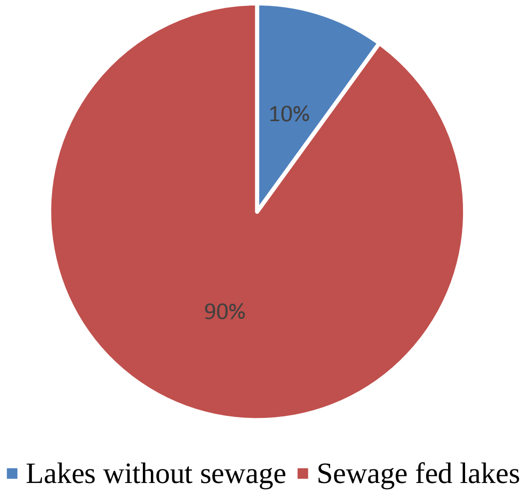
6.0 RESULTS AND DISCUSSION

The current investigation focused on 105 lakes (water bodies) in Bangalore. Among these one season monitoring was done in 25 lakes as these lakes were covered with macrophytes – water hyacinth throughout the year. The study reveals that about 98% lakes have been encroached and about 90% lakes are affected due to the sustained inflow of untreated sewage and industrial effluents.





Encroachment	Sustained inflow of sewage and effluents

Physico-chemical characteristics of Bangalore lakes: The physical and chemical integrity of an ecosystem decides its biological integrity and ecosystem services. Physico-chemical characteristics of 80 lakes belonging to the 3 different valleys namely, Koramangala-Challaghatta Valley (KC), Vrishabavathi Valley (V) and Hebbal Valley (H) were monitored to understand the prevailing physic-chemical condition of lakes in Bangalore (figure 6.1). The physico-chemical parameters analysed were water temperature; pH; total dissolved solids; electrical conductivity; turbidity; dissolved oxygen; chemical oxygen demand; biochemical oxygen demand; total alkalinity; chloride; total hardness; calcium hardness; magnesium hardness; nitrate; orthophosphate; sodium and potassium.

The water quality analysis was carried out of the monthly water samples collected from lakes in Bangalore and the results are presented in figure 6.1, which revealed that lakes in Koramangala-Challaghatta Valley (KC) are the most polluted than the lakes in Vrishabavathi Valley (V) and Hebbal Valley (H). The result shows that KC valley receives lot of wastewater than the other two valleys. At inlets of KC Valley lakes, higher ionic and organic contents except phosphate were noticed. The physico-chemical parameters in inlets of different Valleys are in the order KC > V > H.

At middle part, KC valley has higher TDS, EC, pH, COD, chloride, hardness, nitrate, sodium and potassium. Alkalinity and DO are higher in Vrishabavathi Valley and support more phytoplankton growth. The physico-chemical parameters in middle part of different Valleys are in the order KC > H > V.

At outlets, KC valley has higher TDS, EC, COD, BOD, chloride, hardness and sodium. Alkalinity and DO are higher in Vrishabavathi Valley as the lakes support more algae growth. Hebbal Valley has higher pH, turbidity, orthophosphate, sodium and potassium. The physico-chemical parameters in outlet of different Valleys are in the order KC > H > V. Lakes in Hebbal valley have high phosphate content at the inlet, middle and outlet.

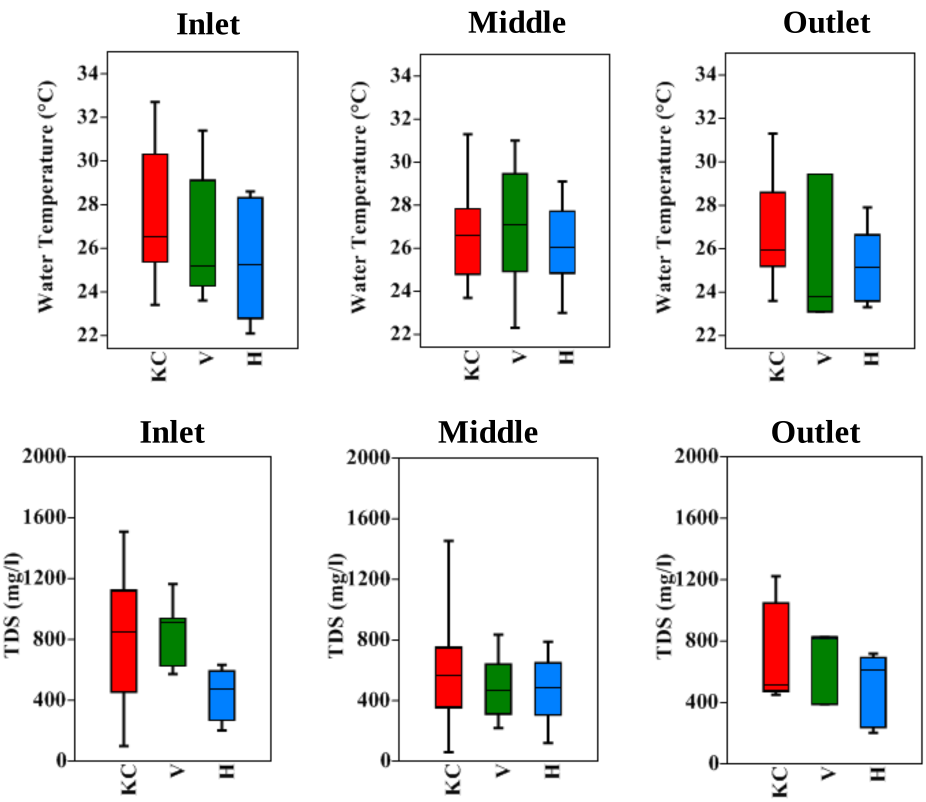
The inlet part of lakes has higher physico-chemical parameters than the middle and outlet part of lakes because of the sustained inflow of untreated sewage (Sincy et al., 2014). The continuous entry of sewage water and rainwater runoff to lakes also reduces the depth of the lake and ground water recharge capacity apart from contaminating ground water sources (Ramachandra et al., 2015b).

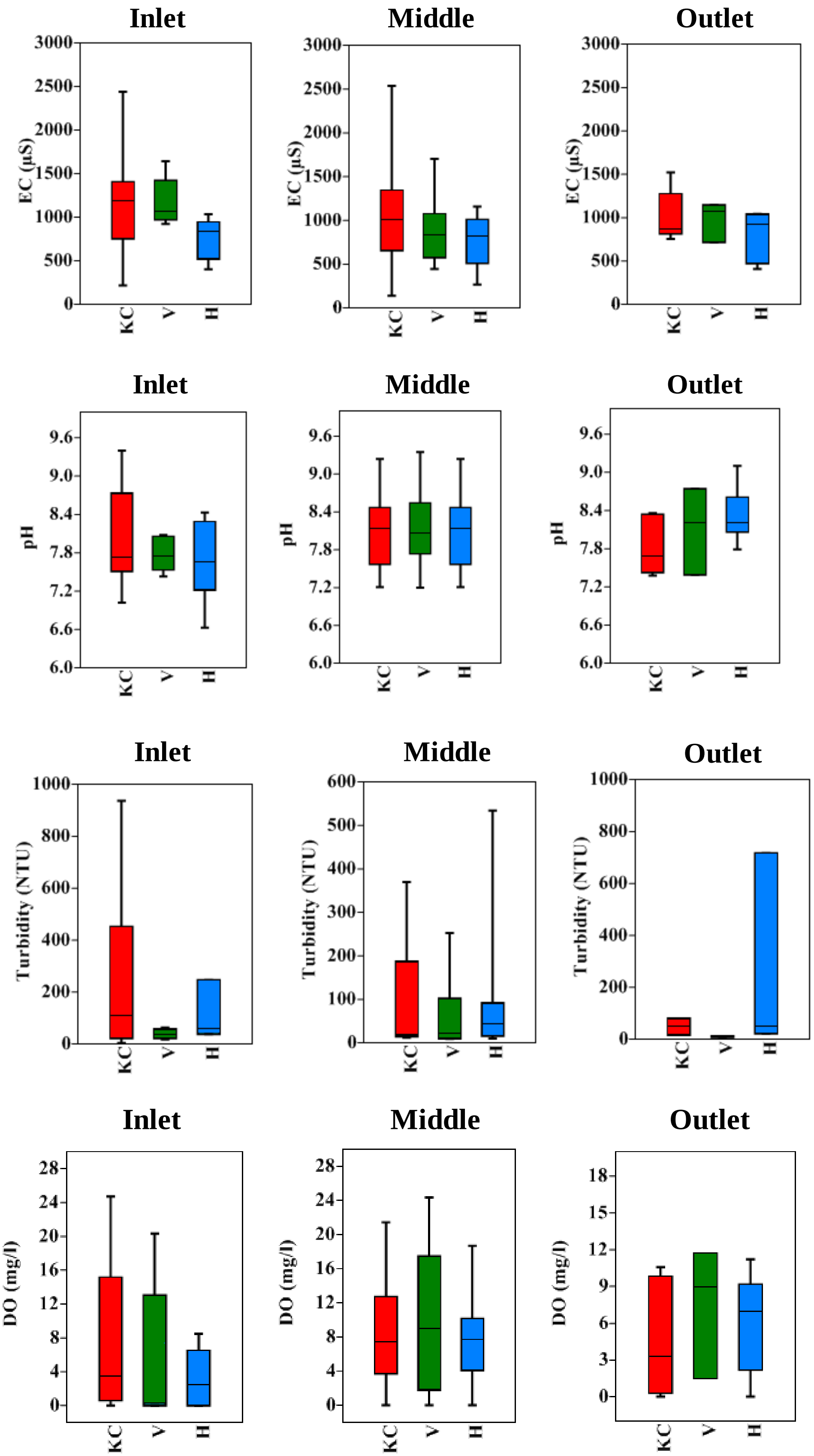
All parameters showed seasonal variations and the variations in water temperature are influenced by factors like air temperature, humidity, wind and solar energy (Sincy et al., 2012). The variation in TDS and EC is related to the concentration of calcium, magnesium, sodium, and potassium cations and carbonate, bicarbonate, chloride, sulfate, and nitrate anions in lake water (Ramachandra et al., 2015a, 2003). The increase in conductivity is due to the sustained inflow of untreated effluents (through both domestic and industrial sources) into lakes/wetlands (Alakananda et al., 2013). Higher pH values are attributed to higher photosynthetic rates of algae, using more dissolved CO_2 from the waters and thereby, causing high bicarbonate and carbonate concentrations (alkalinity). High carbonates cause calcium and magnesium ions to form insoluble minerals leaving sodium as the dominant ion in solution (Mahapatra et al., 2013). Higher turbidity values in lakes are mainly due to silt, organic matter, sewage (domestic) and other effluents (Kiran and Ramachandra, 1999).

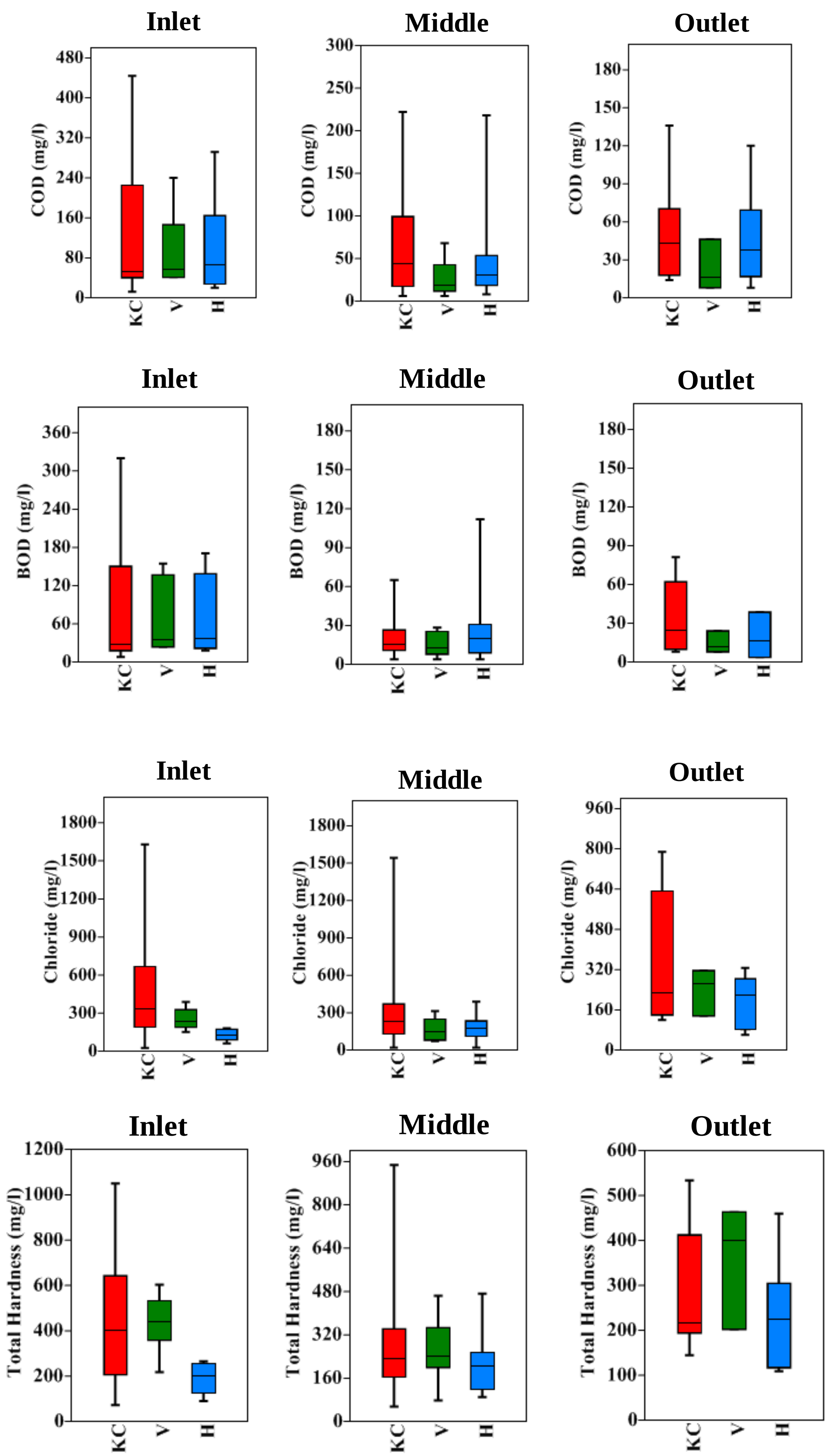
Hypoxic and even anoxic condition due to low dissolved oxygen content can be attributed to the sustained inflow of organic load, water hyacinth cover and decomposition of organic matter (Ramachandra et al., 2013). The roots of the floating macrophytes provide a good substratum for the attachment of bacteria, which drastically reduces the DO levels, resulting in hypoxia and anoxia (Mahapatra et al., 2011a). Fish death in lakes due to asphyxiation occurs due to the sudden fall in DO levels with sewage influx into lakes (Benjamin et al., 1996). Higher levels of BOD in the urban lakes can be attributed to sewage inflow through storm water drains and reduced circulation in water bodies. These also indicate higher levels of biodegradable organic matter, higher rate of oxygen consumption by heterotrophic organisms and a high rate of organic matter mineralization (Mahapatra et al., 2010). Higher values of COD indicate pollution due to oxidisable organic matter (Sincy et al., 2014). Lakes having continuous sewage inflow, low water levels and highly stressed by anthropogenic activities have high levels of COD.

Lakes with continuous inflow of sewage have high concentrations of total hardness, alkalinity and chlorides (Ramachandra et al., 2013). Elevated chloride values could be due to many factors, including sewage, industrial effluents, and agricultural runoff. Potassium is also an essential element for plant growth. Its elevated levels indicate potential contamination from industrial effluents or fertilizer (Ramachandra, 2008). The main cause of hardness in natural water is due to calcium and magnesium salts combined with carbonates and bicarbonates. The main source of hardness is domestic and industrial washing flowing into the lake (Ramachandra et al., 2001)

Phosphate occurs in water in various forms like orthophosphates, condensed phosphates and naturally found phosphate. The increased phosphate in lake water is due to detergents, fertilizers and due to biological processes. Inorganic phosphorus is a limiting nutrient and plays an important role in aquatic ecosystems. Inorganic phosphorus in excess amounts along with nitrates and potassium causes algal bloom (Balachandran et al., 2012). When lakes receive nutrients, a substantial part is taken up by biota, leading to algal and macrophytes bloom. Macrophytes ultimately die, decompose and settles as sludge sediment in the lake bottom and with high turbulence and overflow of water during monsoon they are likely to be transported to downstream. Thus, sludge/sediments act as a major sink for C, N and P (Mahapatra et al., 2011c). Nutrients trapped in sediments gets released during monsoon with high intensity of rainfall with upwelling of sediments and churning of lake water. Phosphates leads to frothing, which are observed at the outlets of large water bodies. Nitrate at higher concentrations primarily contribute to the eutrophication of water bodies. Anoxic conditions do not favour ammonia (NH_4) to be nitrified to a large extent. Low DO (0 mg/l) favours denitrification process (Mahapatra et al., 2011b).




Inlet
Middle
Outlet
EC (µS)
0
500
1000
1500
2000
2500
3000
KC
V
H
pH
6.0
6.6
7.2
7.8
8.4
9.0
9.6
Turbidity (NTU)
0
200
400
600
800
1000
100
300
500
DO (mg/l)
0
4
8
12
16
20
24
28
3
6
9
15
18


Inlet
Middle
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BOD (mg/l)
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Inlet
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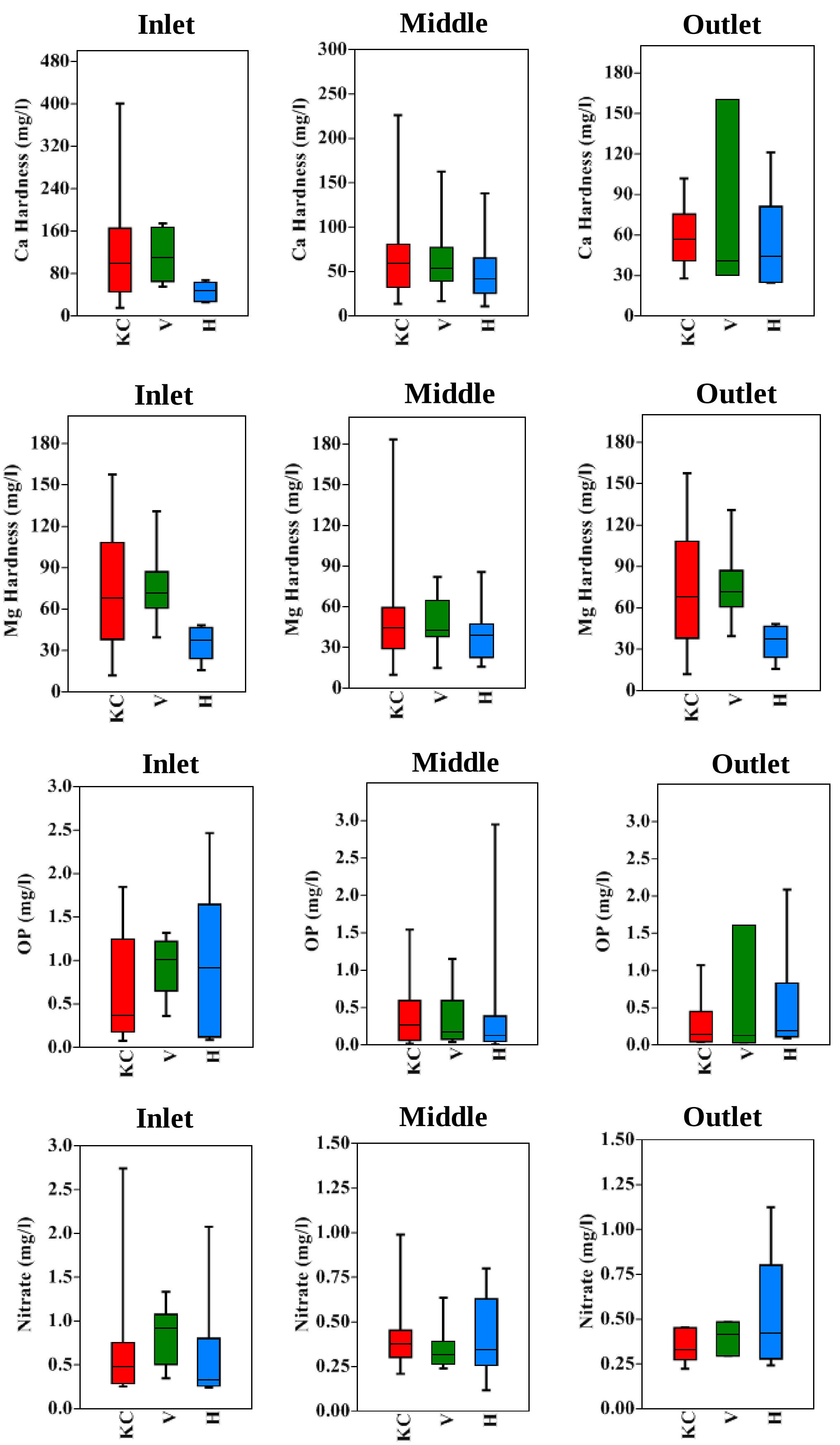
Outlet
Chloride (mg/l)
KC
V
H
Inlet
Middle
Outlet
Total Hardness (mg/l)
KC
V
H


Inlet
Middle
Outlet
Ca Hardness (mg/l)
Mg Hardness (mg/l)
OP (mg/l)
Nitrate (mg/l)
KC
V
H

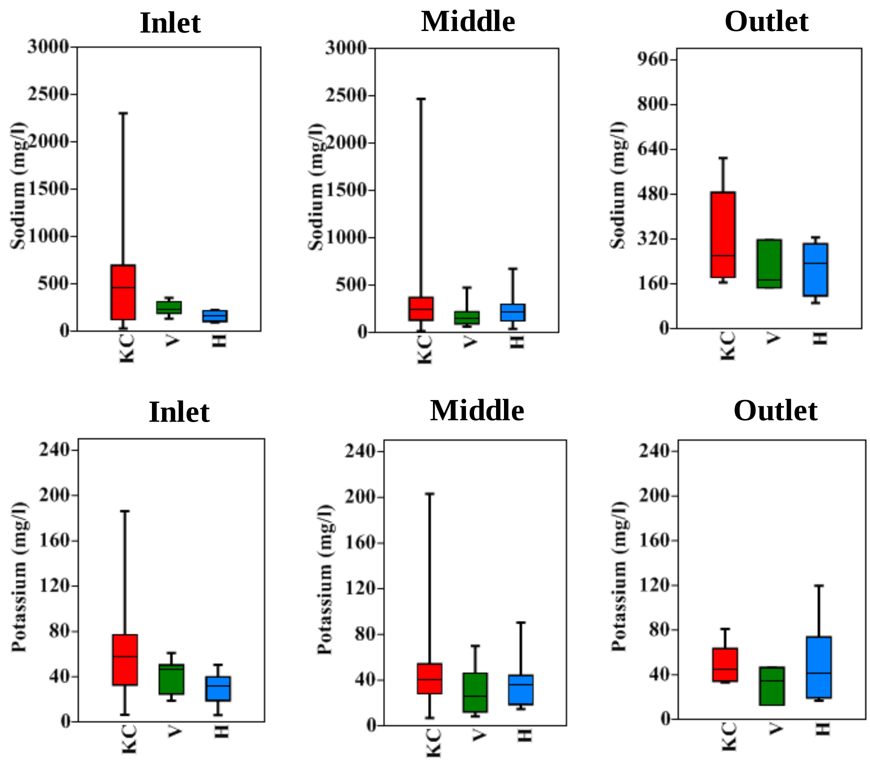


Figure 6.1: Variation of physico-chemical parameters in lakes belonging to Koramangala-Challaghatta Valley (KC), Vrishabavathi Valley (V) and Hebbal Valley (H) in Bangalore

Cluster Analysis: The Cluster Analysis of physical and chemical variables in the water of 80 lakes in Bangalore revealed the existence of three groups (figure 6.2 and 6.3).

- Group-**a**, 24 lakes, which are less polluted lakes that have low ionic as well as nutrient contents: Sompura, Bellahalli, Doraikere, Mylasandra 1, Hesaraghatta, Vittasandra, Mylasandra 2, Munnekolala, Palanahalli, Narsipura 1, Ulsoor, Uttarahalli, Rachenahalli, Agara, Rayasandra, Narasipura 2, Yelahanka, Deepanjali Nagara kere, Bagmane, Kengeri, Hebbal, Nagavara, Kogilu and Mathikere..
- Group-**b**, 22 lakes, which are moderately polluted lakes that have low ionic as well as nutrient contents compared to Group c but supports algal and macrophyte growth: Chikkabanavara, Yeklgata, Hemmigepura, Komghatta, Baallehannu, Andrahalli, Chikka Togur, Subbarayanna, Kelagiankare, Thirumenahalli 2, Jakkur, Kaikondrahalli, Kasavanahalli, Madivala, Kothanur, Yediyur, Lalbagh, Sankey, Kattigenahalli, Dasarahalli, Chokkanahalli and Thirumenahalli 1.
- Group-**c,** 34 lakes, which includes highly polluted lakes that have high ionic contents, rich in nutrients and have high oxygen demand due to high organic contents. These lakes are highly stressed due to anthropogenic activities - Kammasandra1, Hebbagodi, Bommasndra, Kammasandra 2, Ambalipura, Singasandra, Bhattrahalli, Begur, Konanakunte, Doddanekundi, Nallurahalli, Chinnappanahalli, KR Puram, Ullal, Anchepalya, Sheelavanthakere, Chunchugatta, Hulimavu, Herohalli, Kundalahalli, Chikka Begur, Dubasipalya, Chikkabettahalli, Allalasandra, Yelemallappashetty, Bellandur, Varthur, Maragondanahalli, Arekere, Mahadevapura, Chelekere, Mallathhalli, Kalkere and Rampura.

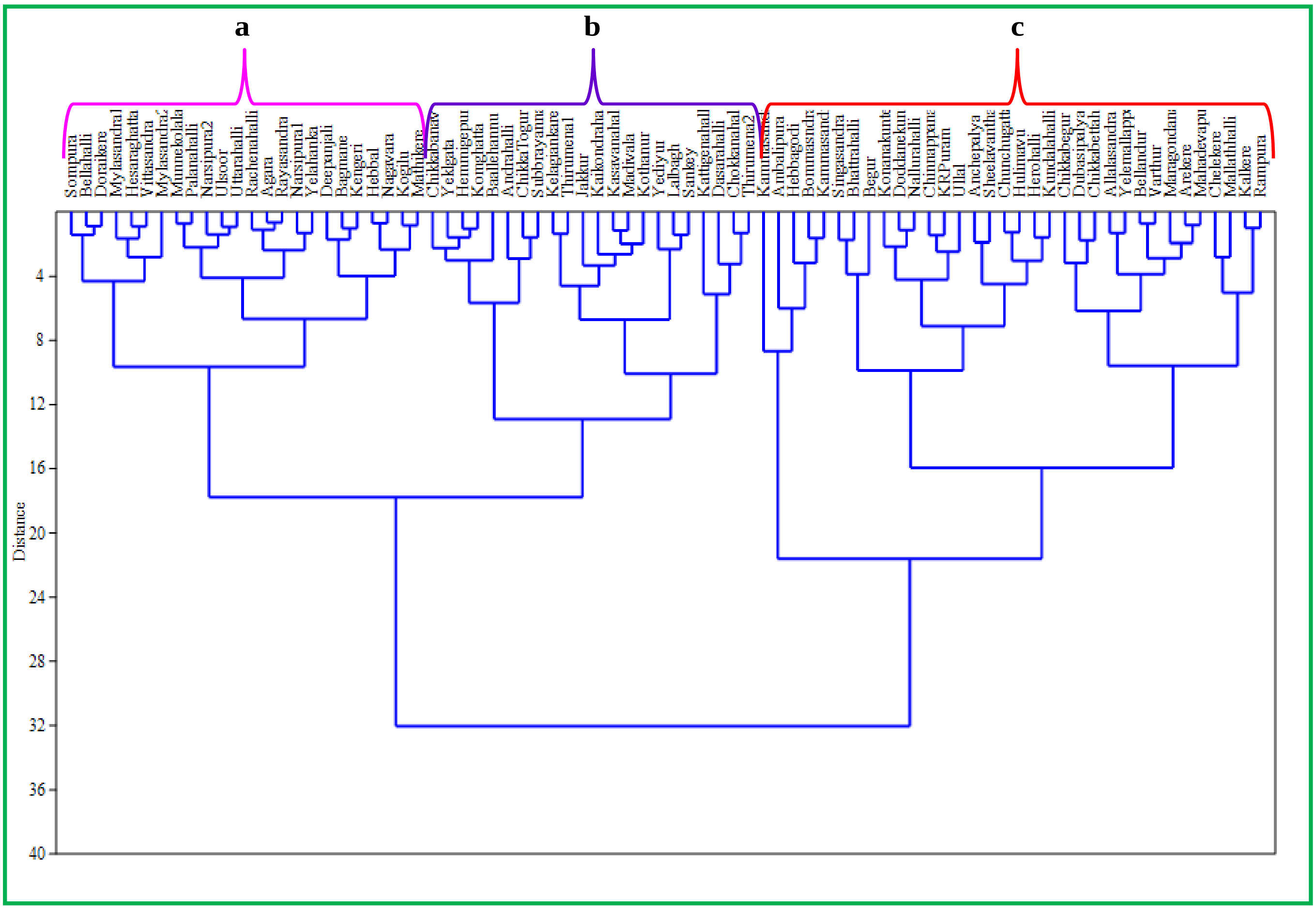


Figure 6.2: Hierarchical clustering analysis (Wards method) of 80 lakes in Bangalore based on physico-chemical parameters (like water temperature, pH, TDS, EC, DO, COD, total alkalinity, chlorides, total hardness, calcium hardness, magnesium hardness, nitrate and ortho-phosphate).

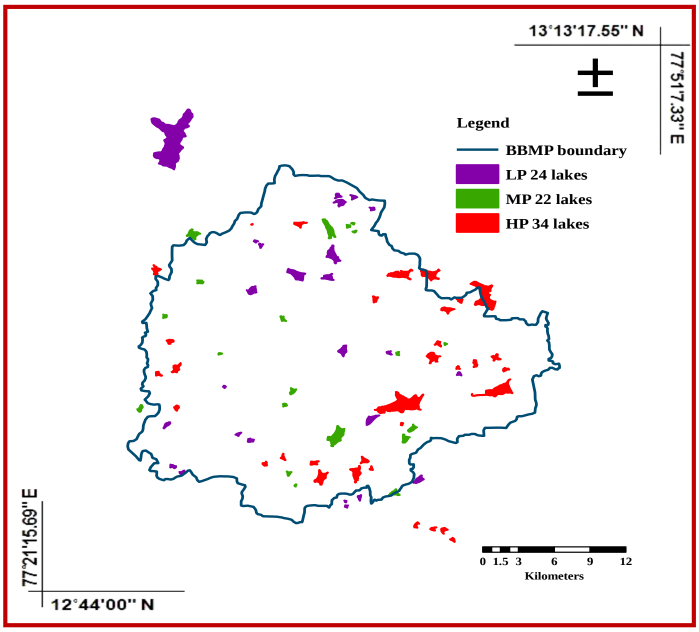


Figure 6.3: Distribution of lakes based on hierarchical clustering analysis (Wards method) - less polluted (LP), moderately polluted (MP), highly polluted (HP) lakes

Principal Component Analysis: Principal component analysis (PCA) was performed to investigate the factors that caused variations in the observed water quality variables across various lakes in Bangalore district. PCA provides information on the most meaningful parameters, which will describe the whole data set, and help in data reduction with minimum loss of original information.

Based on the eigenvalues scree plot (figure 6.3), about 13 physicochemical parameters were reduced to 10 main factors (factors 1 to 10) from the leveling off point(s) in the scree plot. The remaining 3 factors have eigenvalues of less than unity. The table 6.1 shows the corresponding eigenvalues and total variance for each factor extracted. Any factor with an eigenvalue greater than 1 is considered significant. The first factor corresponding to the largest eigenvalue (5.22) accounts for approximately 40.19% of the total variance. The second factor corresponding to the second eigenvalue (2.10) accounts for approximately 16.16% of the total variance.

Table 6.1: Eigenvalues and total variance of water quality parameters on significant principal components

PC	Eigenvalue	% variance
1	5.22	40.19
2	2.10	16.16
3	1.61	12.39
4	1.02	7.83
5	0.85	6.50
6	0.70	5.39
7	0.51	3.90
8	0.38	2.92
9	0.35	2.69
10	0.15	1.19
11	0.086	0.66
12	0.02	0.18
13	0.001	0.01

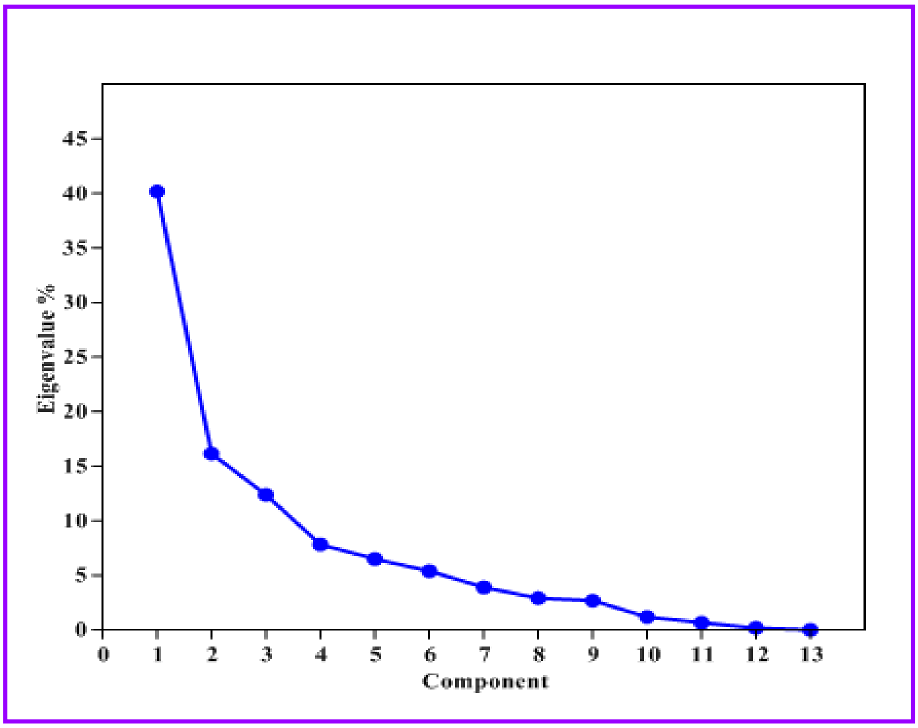


Figure 6.3: Scree plot of the eigenvalues of principal components

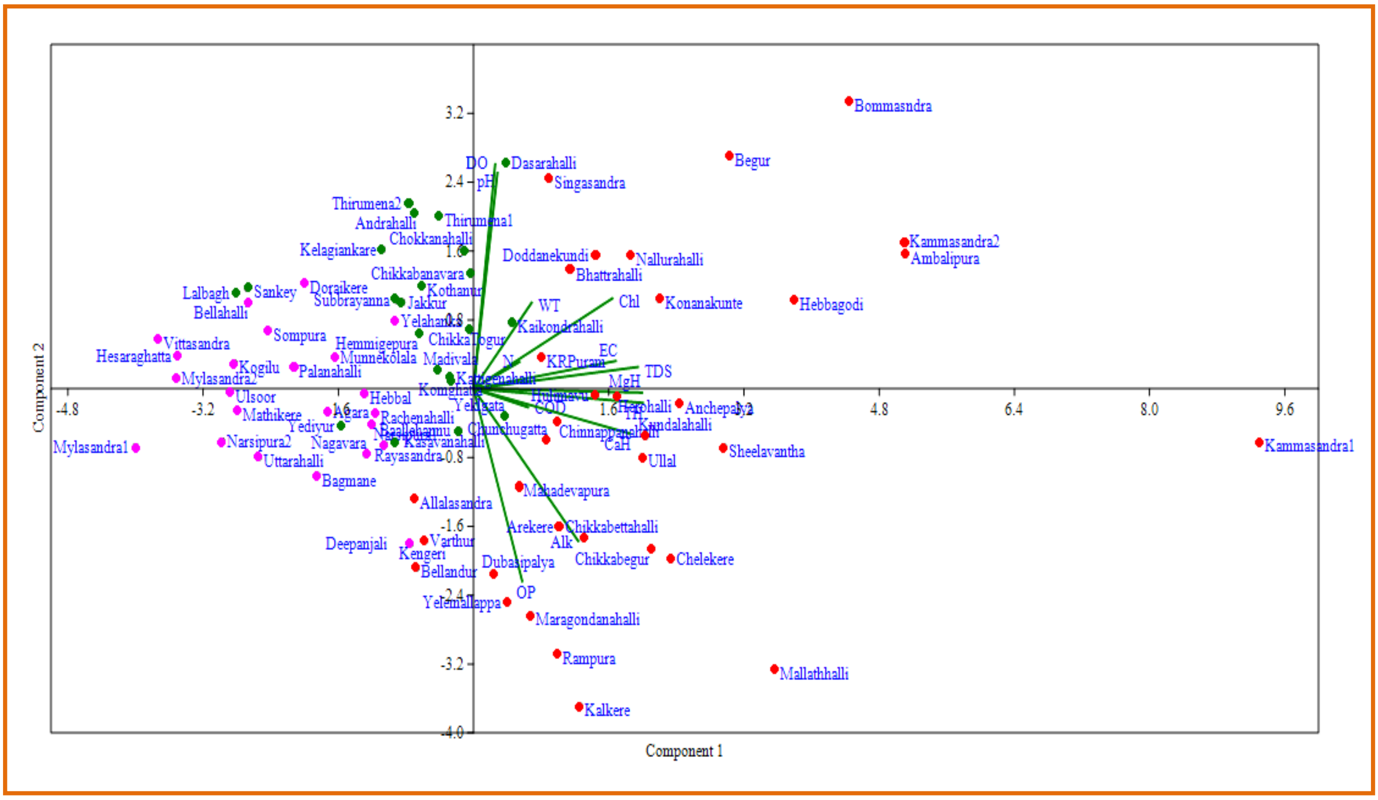


Figure 6.4: Principal component analysis for physico-chemical parameters of lakes in Bangalore

Principal component analysis for physico-chemical parameters of lakes in Bangalore (figure 6.4), revealed that

- Kammasandra 1 and Begur have higher TDS, EC, pH, COD, Total alkalinity, Total hardness, Calcium and Magnesium hardness and Nitrate.
- Yelemallappashetty, Rampura, Kalkere, Maragondanahalli, Mallathhalli, Chikka Togur, Chikka Begur, Allalasandra and Chelekere are highly influenced by orthophosphate as these lakes receive large amount of sewage water.
- Yelemallappashetty, Kammasandra 1, Ullal, Chelekere and Baallehannu are highly influenced by alkalinity. Kammasandra 1, Kattigenahalli and Chokkanahalli have higher Nitrate concentrations. Kammasandra 1, Kammasandra 2, Ambalipura, Hebbagodi, Bommasndra, Begur, Sheelavanthakere, Chikkabettahalli, Chikka Begur, Chikka Togur, Mallathhalli, Anchepalya, Herohalli and Ullal are affected by high levels of Hardness (TH, CaH and MgH).
- The lakes such as Kammasandra 1, Kammasandra 2, Begur, Hebbagodi, Ambalipura, Anchepalya and Bommasndra are highly influenced by chloride content.
- Andrahalli, Bommasndra, Singasandra, Thirumenahalli 1, Doddanekundi, Nallurahalli, Singasandra and Jakkur have high DO.
- Chikkabanavara, Dasarahalli, Chokkanahalli, Kelagiankare, Lalbagh, Sankey, Nallurahalli, Kothanur, Konanakunte, Thirumenahalli 1, Thirumenahalli 2 and Begur are highly affected by pH.
- Yelemallappashetty, Mallathhalli, Bellandur, Chikka Begur, Dubasipalya, Deepanjali Nagara kere, Kengeri, Kalkere, Arekere, Varthur, Maragondanahalli, Rampura and Bagmane are negatively correlated with DO.

The variation in water temperature had affected various parameters like pH, alkalinity, dissolved oxygen, electrical conductivity etc. and also various chemical and biological reactions such as solubility of oxygen, carbon dioxide, carbonate – bicarbonate equilibrium, and the metabolic rate.

In case of Hebbal Valley, 72% of lakes belong to class E and 28% belongs to class D and E. About 87% of lakes in Koramangala-Challaghatta Valley belongs to class E, 8% class D and E and 5% belongs to class A. In case of Vrishabavathi Valley, 69% of lakes belong to class E and 31% belongs to class D and E. When we consider all the sampled lakes in Bangalore, about 79% of lakes belongs to class E, 19% class D and E and 2% belongs to class A (figure 6.5, table 6.2).

Table 6.2: The water quality results based on Classification of Inland Surface Water (CPCB)

Sl.No	Name of the Lake	The valley to which lake belongs	Class
1	Agara Lake	Koramangala-Challaghatta Valley	E
2	Ambalipura Lake	Koramangala-Challaghatta Valley	E
3	Arekere Lake	Koramangala-Challaghatta Valley	E
4	Bagmane Lake	Koramangala-Challaghatta Valley	E

5	Bhattrahalli Lake	Koramangala-Challaghatta Valley	E
6	Begur Lake	Koramangala-Challaghatta Valley	E
7	Bellandur Lake	Koramangala-Challaghatta Valley	E
8	Bommasndra Lake	Koramangala-Challaghatta Valley	E
9	Chikkabegur Lake	Koramangala-Challaghatta Valley	E
10	Chikka Togur Lake	Koramangala-Challaghatta Valley	E
11	Chinnappanahalli Lake	Koramangala-Challaghatta Valley	E
12	Chunchugatta Lake	Koramangala-Challaghatta Valley	E
13	Doddanekundi Lake	Koramangala-Challaghatta Valley	E
14	Hebbagodi Lake	Koramangala-Challaghatta Valley	E
15	Hulimavu Lake	Koramangala-Challaghatta Valley	E
16	Kaikondrahalli Lake	Koramangala-Challaghatta Valley	D and E
17	Kammasandra Lake 1	Koramangala-Challaghatta Valley	E
18	Kammasandra Lake 2	Koramangala-Challaghatta Valley	E
19	Kasavanahalli Lake	Koramangala-Challaghatta Valley	E
20	Kelagiankare Lake	Koramangala-Challaghatta Valley	E
21	Kothanur Lake	Koramangala-Challaghatta Valley	E
22	K R Puram Lake	Koramangala-Challaghatta Valley	E
23	Kundalahalli Lake	Koramangala-Challaghatta Valley	E
24	Lalbagh Lake	Koramangala-Challaghatta Valley	D and E
25	Madivala Lake	Koramangala-Challaghatta Valley	E
26	Mahadevapura Lake	Koramangala-Challaghatta Valley	E
27	Munnekolala Lake	Koramangala-Challaghatta Valley	E
28	Mylasandra Lake 1	Koramangala-Challaghatta Valley	A
29	Mylasandra Lake 2	Koramangala-Challaghatta Valley	A
30	Nallurahalli Lake	Koramangala-Challaghatta Valley	E
31	Rayasandra Lake	Koramangala-Challaghatta Valley	E
32	Sheelavanthakere Lake	Koramangala-Challaghatta Valley	E
33	Singasandra Lake	Koramangala-Challaghatta Valley	E
34	Subbrayanna Lake	Koramangala-Challaghatta Valley	E
35	Ulsoor Lake	Koramangala-Challaghatta Valley	E
36	Varthur Lake	Koramangala-Challaghatta Valley	E
37	Vittasandra Lake	Koramangala-Challaghatta Valley	E
38	Yediyur Lake	Koramangala-Challaghatta Valley	D and E
39	Yeklgata Lake	Koramangala-Challaghatta Valley	E
40	Anchepalya Lake	Vrishabavathi Valley	E
41	Andrahalli Lake	Vrishabavathi Valley	D and E
42	Baallehannu Lake	Vrishabavathi Valley	D and E
43	Dasarahalli Lake	Vrishabavathi Valley	E
44	Deepanjali Nagara Lake	Vrishabavathi Valley	E
45	Doraikere Lake	Vrishabavathi Valley	D and E
46	Dubasipalya Lake	Vrishabavathi Valley	E
47	Hemmigepura Lake	Vrishabavathi Valley	D and E

48	Herohalli Lake	Vrishabavathi Valley	D and E
49	Kengeri Lake	Vrishabavathi Valley	E
50	Komghatta Lake	Vrishabavathi Valley	E
51	Konanakunte Lake	Vrishabavathi Valley	E
52	Mallathhalli Lake	Vrishabavathi Valley	E
53	Sompura Lake	Vrishabavathi Valley	E
54	Ullal Lake	Vrishabavathi Valley	E
55	Uttarahalli Lake	Vrishabavathi Valley	E
56	Allalasandra Lake	Hebbal Valley	E
57	Bellahalli Lake	Hebbal Valley	E
58	Chelekere Lake	Hebbal Valley	E
59	Chikkabettahalli Lake	Hebbal Valley	E
60	Chikkabanavara Lake	Hebbal Valley	E
61	Chokkanahalli Lake	Hebbal Valley	E
62	Hebbal Lake	Hebbal Valley	D and E
63	Hesaraghatta Lake	Hebbal Valley	D and E
64	Jakkur Lake	Hebbal Valley	D and E
65	Kalkere Lake	Hebbal Valley	E
66	Kattigenahalli Lake	Hebbal Valley	E
67	Kogilu Kere	Hebbal Valley	D and E
68	Maragondanahalli Lake	Hebbal Valley	E
69	Mathikere Lake	Hebbal Valley	E
70	Nagavara Lake	Hebbal Valley	D and E
71	Narsipura Lake 1	Hebbal Valley	D and E
72	Narsipura Lake 2	Hebbal Valley	E
73	Palanahalli Lake	Hebbal Valley	E
74	Rachenahalli Lake	Hebbal Valley	D and E
75	Rampura Lake	Hebbal Valley	E
76	Sankey Lake	Hebbal Valley	E
77	Thirumenahalli Lake 1	Hebbal Valley	E
78	Thirumenahalli Lake 2	Hebbal Valley	E
79	Yelahanka Lake	Hebbal Valley	E
80	Yelemallappashetty Lake	Hebbal Valley	E

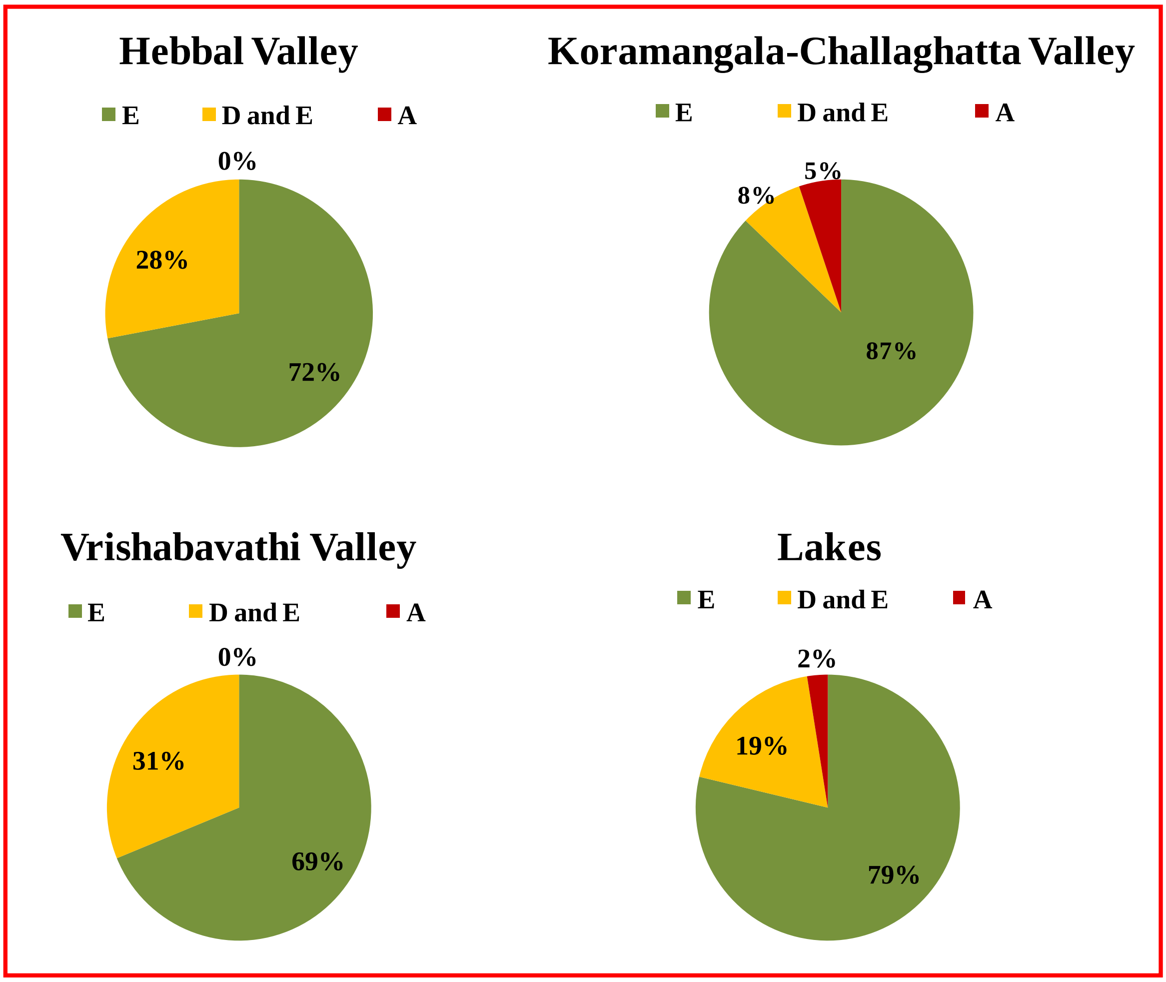


Figure 6.5: The class-wise distribution of the lakes in Bangalore belonging to 3 different valleys

CONCLUSION

An exploratory survey of 105 lakes in Bangalore revealed that about 25 lakes were found to be in a very bad state (either lakes had little/no water). The physico-chemical characteristics of 80 lakes were assessed to understand the prevailing condition of lakes in Bangalore.

- The water quality results revealed that lakes such as Andrahalli, Baallehannu, Doraikere, Hebbal, Hemmigepura, Herohalli, Hesaraghatta, Jakkur, Kaikondrahalli, Kogilu, Lalbagh, Nagavara, Narsipura 1, Rachenahalli and Yediyur falls under Class D and E, whereas all the other 63 lakes belonged to under Class E based on the Classification of Inland Surface Water (CPCB).
- Lakes in Koramangala-Challaghatta Valley (KC) are the most polluted than the lakes in Vrishabavathi Valley (V) and Hebbal Valley (H).
- About 79% of lakes monitored in Bangalore belongs to class E, 19% to class D and E and 2% belongs to class A.
- Lakes like Bellandur, Chelekere, Chikkabegur, Chunchugatta, Hebbagodi, Kalkere, Kammasandra lake 1, Kengeri, Mallathhalli, Maragondanahalli, Nallurahalli,

Rampura, Varthur and Yelemallappachetty receives enormous amount of untreated sewage water.

- Cluster Analysis of physical and chemical variables in the water of 80 lakes in Bangalore revealed the existence of three groups namely less polluted, moderately polluted and highly polluted lakes.
- All monitored parameters showed diurnal as well as seasonal variations in the present study.
- Principal component analysis for physico-chemical parameters of lakes revealed that Kammasandra 1, Kammasandra 2, Ambalipura and Begur have higher TDS, EC, pH, COD, Total alkalinity, Total hardness, Calcium and Magnesium hardness.
- An enormous amount of wastewater is generated in Bangalore daily. The treatment capacities of STPs in Bangalore are far lower than generation. Only treated sewage to be let into lakes.
- Lakes that had profuse growth of Algae i.e., Cyanophyceae (due to continuous sewage inflow and high nutrients) are Sankey, Dasarahalli, Bagmane, Ulsoor, Anchepalya, Bommasndra, Kammasandra 1and 2.
- Fish death was seen in Sankey, Lalbagh, Jakkur and Munnekolala.
- In the case of Zooplanktons, Rotifera and Protozoa were present in high numbers in polluted/nutrient rich lake.
- In the case of Macrophytes, *Eichhornia* sp., *Typh*a sp. and *Alternanthera* sp. were the most dominant species found. These macrophytes sometimes cover the entire lake surface resulting in anoxic conditions.
- Foam formation was seen in lakes such as Bellandur, Maragondanahalli, Rampura, Sarakki and Varthur.
- Recently, fire was reported in Bellandur lake.
- Lakes like Bellandur, Bommasndra, Dasarahalli, Deepanjali Nagara, Doddabidirakallu, Kammasandra, Kempambudhi, Mahadevapura, Nalagadderanahalli, Nayandanahalli, Shivapura, Varthur are near to industries.
- STPs are present in lakes like Kempambudhi, Marathahalli, Madivala, Dasarahalli, Lalbagh, Jakkur, Andrahalli, Allalsandra, Hebbal, Herohalli and Doraikere.
- About 25 lakes were found to be places for solid and liquid wastes dumping and fully macrophyte covered due to the excessive amount of nutrients present in those lakes.
- Lake such as Lakasandra had completely turned to a barren land due to the dumping of building debris.
- Immediate action should be taken for the lakes that are in worst conditions.

RECOMMENDATIONS: Immediate policy interventions are essential to protect the lakes from further deterioration, which include:

1. Maintenance of 30 m buffer around the lake (with regulated activities)
2. Mapping of lake boundary and demarcation of lake boundary (based on flood plains), buffer region and valley regions in each valley.

3. Ensure proper fencing of lakes
4. Removal of all encroachments in the lake bed after the survey based on reliable cadastral maps
5. Re-establishing interconnectivity among lakes (removal of all encroachments)
6. Threshold on high raise building in the region. Need to protect valley zones considering ecological function and these regions are ‘NO DEVELOPMENT ZONES’ as per CDP 2005, 2015
7. Digitization of land records (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query based information system to public
8. Any alteration of topography in lake catchments should be banned
9. Complete ban on construction activities in the valley zones
10. Restrictions on the diversion of lakes for any other purposes
11. Regulate illegal sand and clay mining around the wetlands
12. Restrictions on dumping solid and liquid wastes in lakes and lake bed.
13. Restrictions on letting untreated sewage into lakes
14. Allow only treated wastewater (sewage and effluents) into the lake
15. Implementation of ‘polluter pays’ principle as per Water Act, 1974
16. Banning of filling of a portion of lake with building debris
17. Impact of pesticide or fertiliser on wetlands need to be checked
18. Water in the lake must be cleaned or drained completely, if necessary
19. Plant native species of macrophytes in open spaces of lake catchment area
20. Regular harvesting/removal of macrophytes in the lakes like *Eichhornia* sp., *Typh*a sp., *Alternanthera* sp. etc. through manual operations
21. Treatment of wastewater through constructed wetlands and algal ponds (similar to Jakkur lake). Constructed wetlands with shallow algal ponds helps in the removal of nutrients
22. All the settlements alongside the lake should be provided with proper sanitation facilities so as to avoid open defecation
23. The shorelines of the lakes should be lined with bricks or stones to control shoreline erosion
24. Afforestation with native species in the areas around wetlands (catchment area) to control the entry of silt through runoff
25. Dredging of the sediments in the lake has to be done to improve the soil permeability, water holding capacity and ground water recharge. Wet dredging is applicable to lakes
26. Adopt techniques like biomanipulation (Silver carp, Catla, Rohu , Gambusia and Guppies for algal and mosquito control), aeration, shoreline restoration (with the native vegetation) in the management of lakes
27. Single agency with the statutory and financial autonomy to be the custodian of natural resources (ownership, regular maintenance and action against polluters (encroachers as well as those who contaminate through untreated sewage and effluents, dumping of solid wastes)
28. The MSWM (Municipal Solid Waste Management) problem has increased with rapid urbanisation. The public and agencies should follow the Municipal Solid Wastes (Management and Handling) Rules, 2000 to keep the environment clean and to safeguard the health of individuals.
29. Decentralized treatment of wastes generated in each ward, ensure proper functioning of STPs

30. Restore surviving lakes in urban areas strengthening their catchment area
31. Environmental awareness programmes can greatly help in the protection of the water bodies.

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