Aspects of Reservoirs Water Quality – Monitoring and Assesment of Pollution Level

P. P. Mendhe[1], C.D. Garibdas[2] and M.M. Dange[3]

[1]Executive Engineer, Hydrology Project Division, Nagpur
[2]Sub Divisional Engineer, [3]Assistant Engineer – II, Hydrology Project Sub Division, Nagpur
e-mail : hpwglnagpur@rediffmail.com

ABSTRACT

The water quality of lakes and reservoirs is an important subject with respect to environmental pollution and community development. Lakes and reservoirs, being convenient water bodies of surface water are vulnerable to carious problems including eutrophication as they are used for variety of purposes like agriculture, domestic, industrial etc. Municipal waste water, industrial effluents and runoff from fertilized agricultural lands add nutrients that stimulate algal growth and degrades the water quality. The amount of light available is related to the transparency of water which is a function of level of eutrophication.

Water quality Lab. Level-II, Nagpur established under Hydrology Project (Surface Water) is monitoring the water quality of four reservoirs viz. Upper Wardha, Pench, Katepurna & Chapdoh since 2006 for major physical, chemical & biological parameters like solids, nutrients (N, P, etc), minerals (Na, K, Cl etc), organic load (BOD) and microbial parameters (coliforms)

The paper includes water quality data collected, analysed & interpreted in the context of seasonal variations in the water quality of reservoirs and the assessment of pollution level with suitability of the water for various intended uses. The suggestions for preserving the water quality of the reservoirs with reference to the parameters under consideration are also included in the paper.

INTRODUCTION

Water quality characteristics of aquatic environments arise from a multitude of physical, chemical and biological interactions. The water bodies such as rivers, lakes and estuaries are continuously subject to a dynamic state of change with respect to their geological age and geochemical characteristics. This is demonstrated by continuous circulation, transformation and accumulation of energy and matter through the medium of living things and their activities. This dynamic balance in the aquatic ecosystem is upset by human activities resulting in pollution which is manifested dramatically as fish kill, offensive taste and odour etc.

Reservoirs typically receive larger inputs of water, as well as soil and other materials carried in rivers than lakes. As a result, reservoirs usually receive larger pollutant loads than lakes. However, because of greater water inflows, flushing rates are more rapid than in lakes. Thus, although reservoirs may receive grater pollutant loads than lakes, they have the potential to flush the pollutants more rapidly than do lakes (as one can more rapidly flush water from a bathtub by increasing the water flow and/or the rate at which the water is drained from the tub). Reservoirs may therefore exhibit fewer or less severe negative water quality or biological impacts than lakes for the same pollutant load.

All lakes are subject to a natural ageing process known as eutrophication. It is caused by the gradual accumulation of silt and organic matter in the lake. A young lake is characterized by a low nutrient contents and low plant productivity. Such lakes generally acquire nutrients from their drainage basins, which enables increased aquatic growth over time. The increased biological productivity causes the water to become murky with phytoplankton, while decaying organic matter depletes the dissolved oxygen. Gradually the lakes become eutrophic getting shallower and warmer. Though it is a natural process that may take thousands of years, it may be accelerated through human activities. Municipal wastewater, industrial wastes and runoff from fertilised agricultural lands add nutrients that stimulates algal growth and degrade water quality. Such cases are called cultural eutrophication.

The large number of water pollutants may be broadly classified under the following categories.

1. Organic Pollutants
2. Inorganic Pollutants
3. Sediments
4. Radioactive Materials
5. Thermal Pollutants

Lakes and reservoirs being convenient bodies of surface water, are potentially vulnerable to a host of other pollution problems besides eutrophication.

There are many factors that control the rate of production of algae, including the availability of sunlight to power the photosynthetic reactions and the concentration of the nutrients required for the growth. While the amount the sunlight available can be a restricting factor in algal growth, it is not something which could be considered controlling as a way to slow eutrophication. Although the list of the influencing nutrients is quite long including carbon, nitrogen, phosphorous, sulphur, calcium, magnesium, potassium, sodium, iron and perhaps others, the problem is made manageable by focusing on just a single nutrient, usually either phosphorous or nitrogen.(Justus Liebig/1840)

In this paper results of analysis of water samples from four reservoirs viz. Chapdoh, Katepurna, Pench and Upperwardha have been discussed and the recommendations for maintaining water quality are mentioned. The scope of the study is limited to collection and analysis of samples of water from the reservoirs.

MATERIAL AND METHODS

The present study covers the period from2005 to 2008. For the purpose of statistical analysis of the data, water year (June to May) is considered.

The details of the reservoirs under study are presented in Table 1.

Table 1 : Details of Reservoirs studied

Sr. No.	Name of Reservoir	District	Tahsil	Name of River
1	Katepurna	Akola	Barshitakli	Katepurna
2	Upper Wardha	Amravati	Morshi	Wardha
3	Pench	Nagpur	Parshioni	Pench
4	Chapdoh	Yeotmal	Arni	Waghadi

SAMPLING METHODS AND FREQUENCY OF SAMPLING

Three types of grab samples were collected for the study. A 2L of sample collected in PVC container for general physicochemical analysis; 300 ml sample separately collected in BOD bottles for the analysis of DO and 500 ml sample collected in pre sterilized glass bottles for the bacteriological analysis.

The samples were collected at a depth of 30cm from the surface. For collection of samples for dissolved oxygen, specially designed DO sampler was used to avoid the entrapment of air during sampling. The DO in the collected sample was fixed on the site using the DO fixing chemicals (Mangnous Sulphate and Alkali Iodide Azide). The collected samples were transported to the laboratory in an Ice Box maintaining a temperature of 4°C. The samples were collected at a frequency of 1 sample every fortnightly.

On reaching the laboratory, the samples were analysed for the predetermined physicochemical and bacteriological parameters.(Uniform protocol on water quality monitoring, 2005, MoEF, GOI) For the analysis of the samples, analytical procedures specified in the "Standard Analytical Procedures" (SAP) by DHV Consultants, Hydrology Project and the Book, "Standard Methods for Analysis of Water and Wastewater 21st Edition 2005" published by American public health association (APHA) were referred.

The N/P Ratio (Table 5) in a body of water over 20 generally indicate that phosphorous is the limiting nutrient, whereas N/P ratio of 5 or less reflect nitrogen limited system (Thomann and Mueller, 1987).

The data collected during the study period was analysed to study the seasonal variation in the water quality of the reservoirs (tables 3 to 5, fig. 1 to 7).

Table 2: Type of Parameters studied

PARAMETER ID	PARAMETER	CATEGORY	UNIT
General Parameters			
DO	Dissolved oxygen	Chemical	mg/L
TDS	Solids, Total Dissolved	Physical	mg/L
pH	pH	Chemical	pH units
Organic Matter			
BOD	Biochemical Oxygen demand (3days)	Chemical	mg/L
ALK-T	Alkalinity, total	Chemical	mgCaCO3/L
Nutrients			
NO_3	Nitrate	Chemical	mg /L
P-Tot	Phosphorus, total	Chemical	mg P/L
Bacteriological Analysis			
FCol-MPN	Coliforms, Faecal	Biological	MPN/100 mL
Tcol-MPN	Coliforms, Total	Biological	MPN/100 mL

FINDINGS AND CONCLUSIONS

1. Dissolved Oxygen: The dissolved Oxygen level for all the reservoirs was found to be satisfactory when compared to the standard of 5.0 mg/L specified by CPCB for Class A1 waters. The water quality trend shows that the DO concentration is least during monsoon period. This might be due to the sediment discharge containing organic matter from the surface run off causing depletion in DO. During late monsoon period, sediments settle down and also the temperature of water reduces, which results in the increase in the DO level of the waterbody.
2. pH: pH of all the reservoirs under study is found alkaline and is within the limit of 6.5 to 8.5 specified by IS 10500: 1991, except for the reservoir upperwardha during monsoon 2005.
3. TDS: TDS in water is a measure of salinity in water. The water quality graphs shows an increasing trend of TDS for reservoirs Chapdoh, Katepurna and Upperwardha. The reservoir Chapdoh is found to contain the highest TDS contents followed by reservoir katepurna. Although many factirs contribute to the TDS in water, few main contributions are the geological structure of the region and the discharge of waste containing inorganic salts to the waterbody.
4. BOD: BOD of the reservoirs under study are found to violate the CPCB limit of 2.0 mg/L for a class A – I waterbody. The BOD is found to be increased for all the reservoirs during study period. During the year 2005-06, the BOD values for reservoirs Chapdoh, Pench and Upperwardha was found within limit which

Table 3 : Summary of monitoring data collected at the Reservoirs

Para meter	Station	Season								
		Mon 05	Win 05.06	Sum 06	Mon 06	Win 06.07	Sum 07	Mon 07	Win 07.08	Sum 08
DO	Chapdoh	6.8	7.3	7.1	6.9	6.7	6.3	6.3	6.9	6.5
	Katepurna	-	8.3	7.4	6.5	6.5	6.3	6.4	7.3	6.5
	Pench	6.5	7.5	6.9	6.7	6.8	6.6	6.4	7.0	6.7
	Upperwardha	5.5	7.3	6.7	6.4	6.6	6.2	6.2	7.1	6.4
pH	Chapdoh	7.9	8.1	8.2	8.3	8.3	8.3	8.3	8.4	8.4
	Katepurna	-	8.3	8.2	8.3	8.2	8.3	8.4	8.4	8.3
	Pench	8.4	8.3	8.3	8.4	8.2	8.3	8.2	8.3	8.3
	Upperwardha	8.6	8.3	8.3	8.4	8.3	8.4	8.4	8.4	8.4
TDS	Chapdoh	509	271	194	207	247	251	167	247	288
	Katepurna	-	188	219	141	217	162	144	240	294
	Pench	111	154	146	147	191	172	137	165	161
	Upperwardha	113	142	149	146	201	194	147	245	298
BOD	Chapdoh	-	1.3	1.9	1.9	2.7	2.4	2.4	2.4	2.4
	Katepurna	-	2.5	1.8	2.0	2.4	3.3	2.3	2.2	2.2
	Pench	-	1.0	1.5	1.5	1.6	2.4	2.4	2.2	2.1
	Upperwardha	-	1.0	1.5	1.6	2.6	2.4	2.3	2.4	2.0
Total colliforms	Chapdoh	265	37	10	66	34	71	195	30	97
	Katepurna	-	6	308	264	74	15	275	33	16
	Pench	445	14	69	138	156	98	455	163	136
	Upperwardha	250	10	102	357	28	38	594	26	10
Faecal colliforms	Chapdoh	80	9	3	38	6	15	68	3	10
	Katepurna	-	2	114	67	23	4	99	18	5
	Pench	75	8	40	52	29	30	132	46	14
	Upperwardha	30	5	47	102	9	12	170	17	2
Alkalinity	Chapdoh	214	205	153	164	187	173	132	193	197
	Katepurna	-	165	167	131	153	147	127	187	205
	Pench	102	131	146	132	170	147	128	148	147
	Upperwardha	102	126	133	124	161	154	131	196	201
Nitrate	Chapdoh	5.35	1.25	0.10	0.47	0.20	0.22	0.47	0.81	0.35
	Katepurna		0.78	1.11	0.97	1.00	0.78	1.27	3.06	1.15
	Pench	0.89	1.86	0.53	0.80	0.84	0.62	1.64	2.08	1.11
	Upperwardha	0.40	1.09	0.71	1.07	0.68	0.68	1.46	3.37	1.11
Phosphorous	Chapdoh	0.185	0.030	0.044	0.045	0.012	0.028	0.029	0.034	0.069
	Katepurna		0.027	0.023	0.050	0.033	0.021	0.042	0.032	0.061
	Pench	0.043	0.031	0.025	0.030	0.018	0.023	0.042	0.043	0.059
	Upperwardha	0.058	0.014	0.026	0.042	0.021	0.023	0.028	0.036	0.043

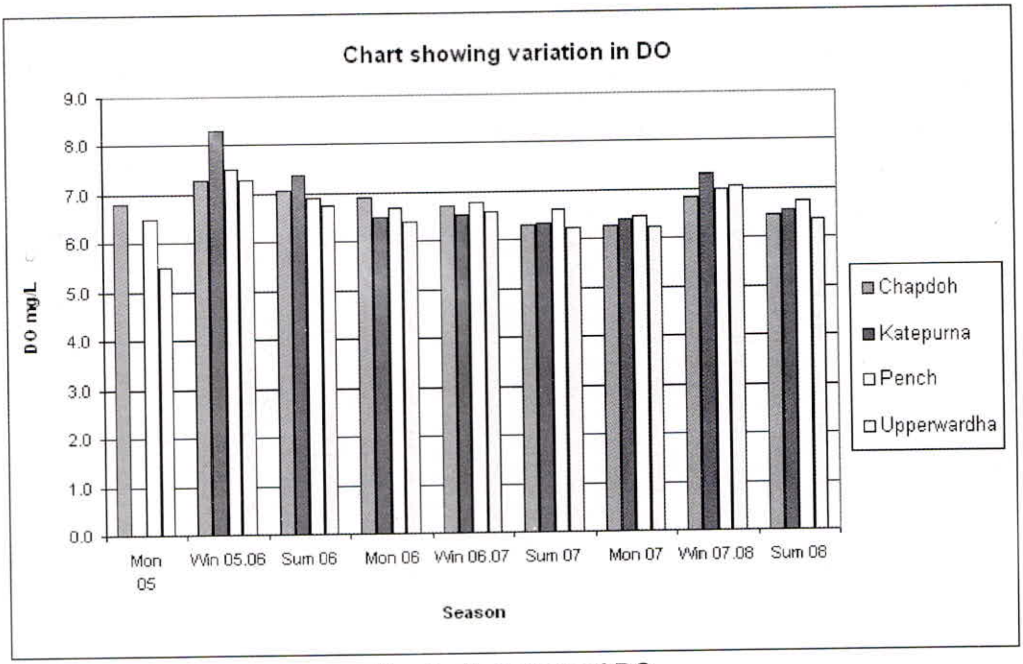

Fig. 1 : Variation of DO

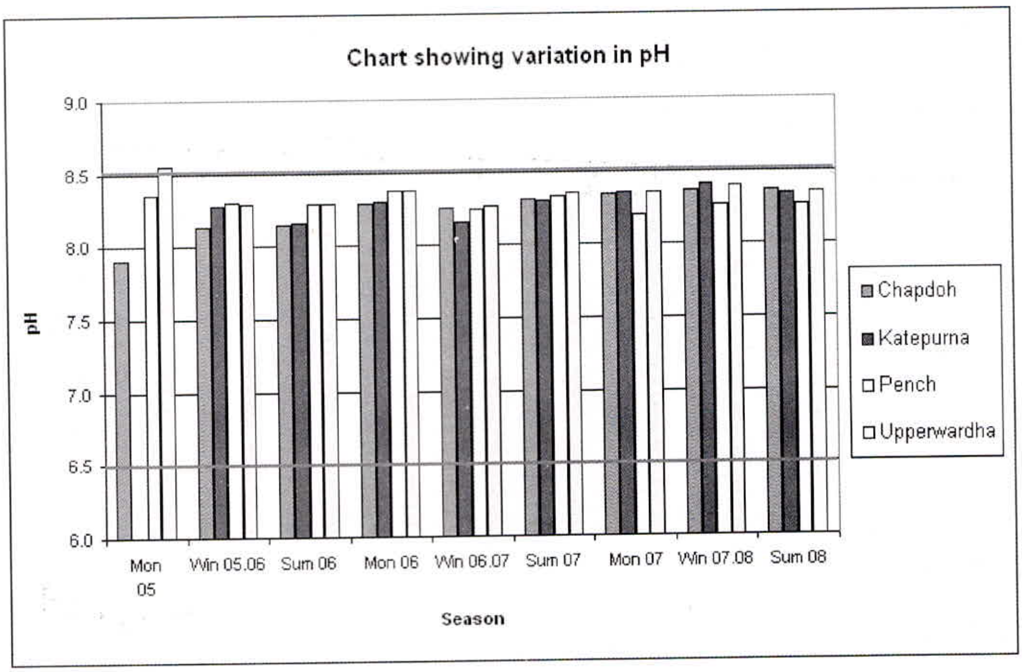

Fig. 2 : Variation of pH

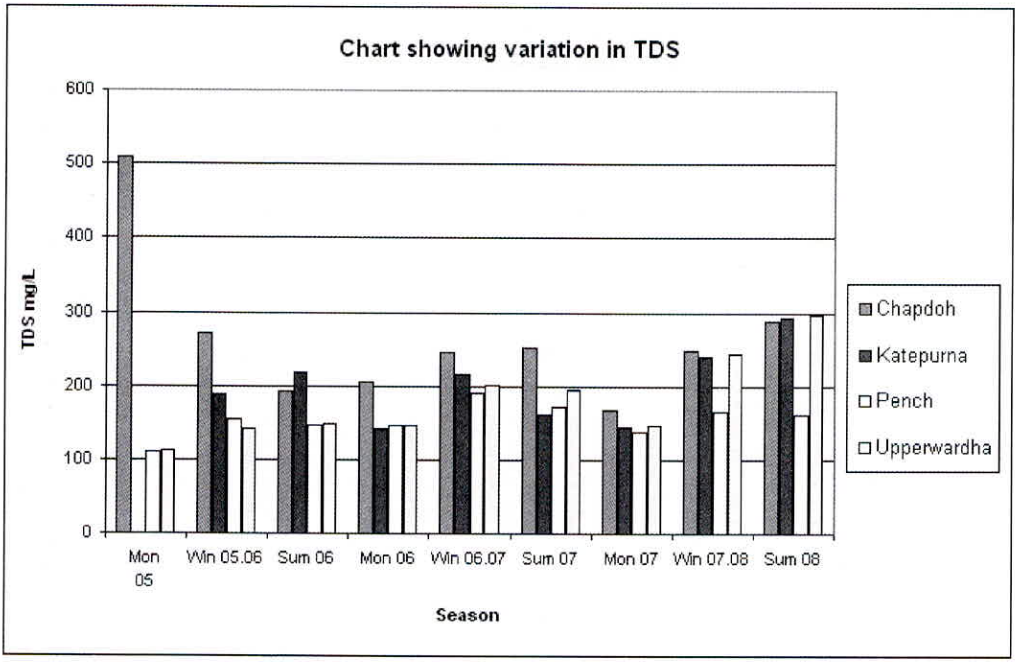

Fig. 3 : Variation of TDS

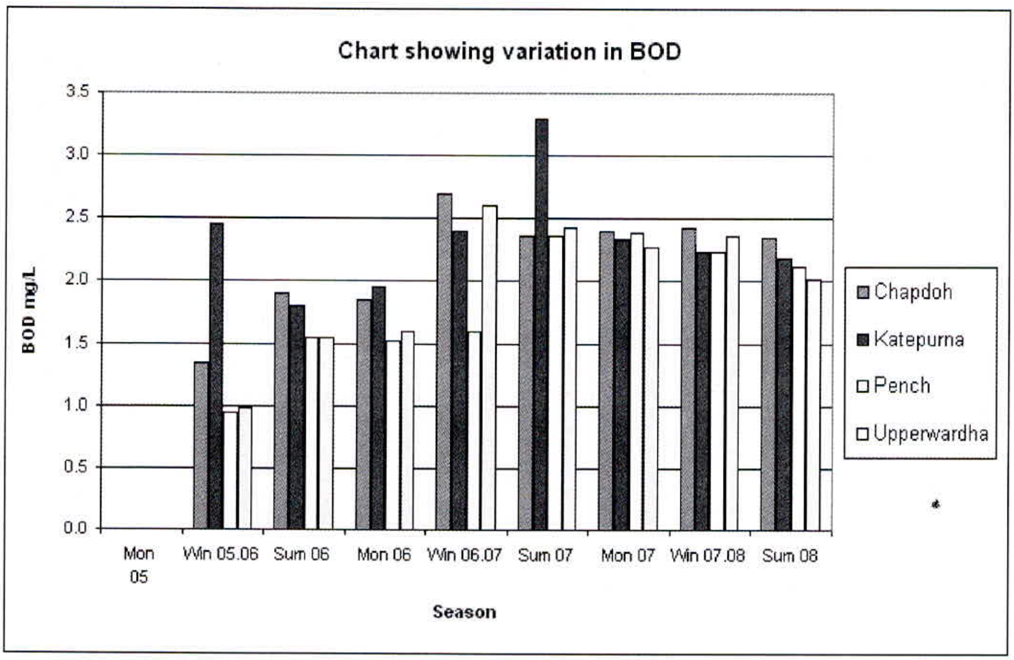

Fig. 4 : Variation of BOD

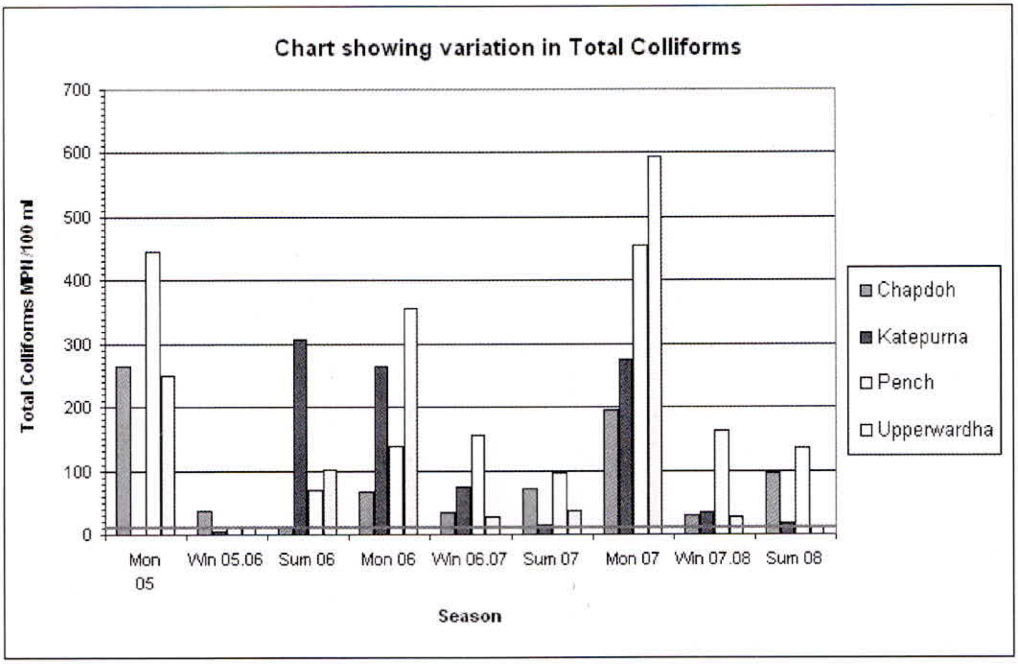

Fig. 5 : Variation of T.C.

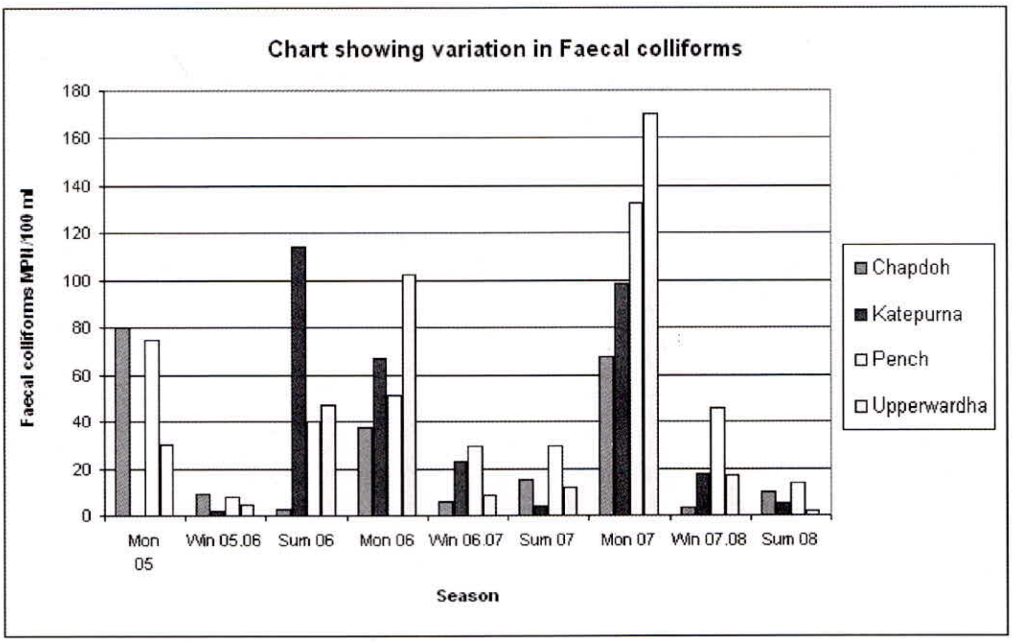

Fig. 6: Variation of F.C.

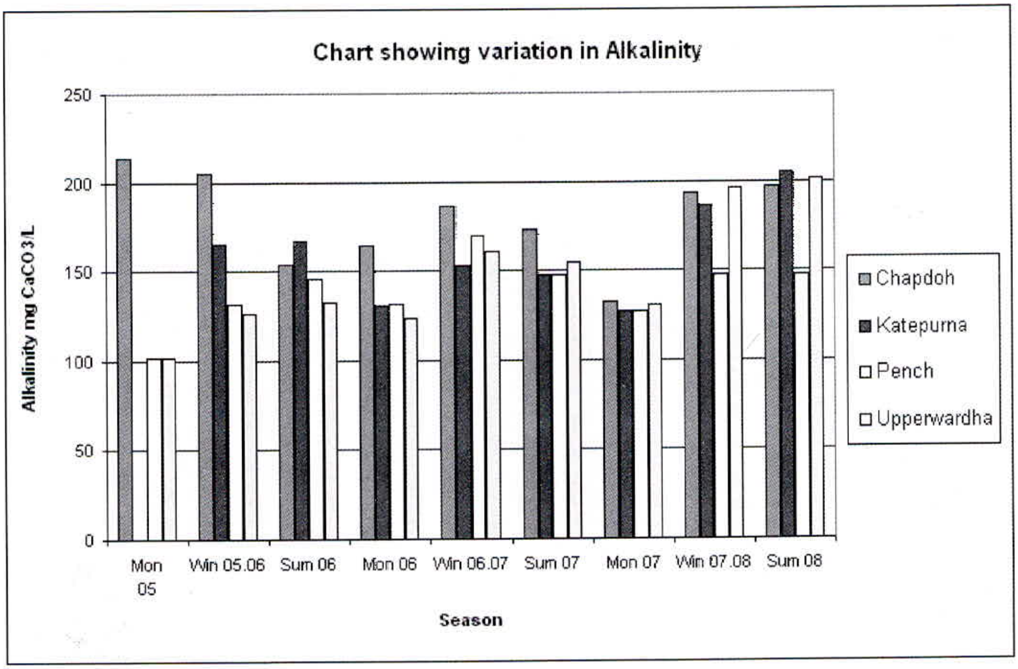

Fig. 7 : Variation of Alkalinity

Table 4 : Water Quality data significant to Irrigation Purpose

Station	Year	Na%	SAR	B
ICAR STANDARD		**60**	**26**	**2 mg/l**
Chapdoh	2005-06	22.67	0.85	0.09
	2006-07	31.45	1.09	0.03
	2007-08	32.70	1.25	0.17
Katepurna	2005-06	21.28	0.77	0.07
	2006-07	18.58	0.50	0.04
	2007-08	32.20	1.25	0.20
Pench	2005-06	17.34	0.50	0.19
	2006-07	12.43	0.34	0.05
	2007-08	15.68	0.41	0.05
Upperwardha	2005-06	20.50	0.60	0.29
	2006-07	25.11	0.74	0.04
	2007-08	35.12	1.43	0.19

Table 5 : N/P ratio

Parameter	2005-06	2006-07	2007-08	Average
Pench				
Nitrogen	0.30	0.17	0.38	0.28
Phosphorous	0.029	0.023	0.046	0.033
N/P ratio	10.31	7.38	8.24	8.64
Chapdoh				
Nitrogen	1.32	0.28	0.51	0.70
Phosphorous	0.052	0.026	0.041	0.039
N/P ratio	25.45	10.92	12.54	16.30
Upperwardha				
Nitrogen	0.18	0.19	0.48	0.28
Phosphorous	0.022	0.027	0.035	0.028
N/P ratio	8.11	7.14	13.80	9.68
Katepurna				
Nitrogen	0.15	0.25	0.45	0.28
Phosphorous	0.027	0.032	0.041	0.033
N/P ratio	5.60	7.74	10.97	8.10

subsequently increased during year 2006-07 anf further in 2007-08. The BOD of the reservoir Katepurna was found on higher side throughout the study period. The main contribution to the BOD of a waterbody is due to the discharge of organic waste to the waterbody and also due to the organic load contributed by biological activities in the waterbody. The increase in the BOD load to the reservoir Pench may be due to the effect of domestic activities in the nearby areas of the waterbody. This is also supported by the higher concentration of colliform bacteria of faecal origin. Whereas in the reservoir Katepurna this might be due to the organic loading from the decay of dead planktons in the waterbody. This is also evidenced by the slight higher level of DO in the reservoir despite of having higher BOD values.

5. Colliform bacteria: The colliform bacteria in all the reservoirs under study are found on higher side with respect to IS 10500: 1991 throughout the study period. In the reservoir Pench, the conc, of bacteria is found highest among all the reservoirs. This might be due to the increasing urbanization in the region. The higher concentration of bacteria in all reservoirs during monsoon periodis due to the surface runoff contributing the large no. of bacteria in the reservoirs. Considering the aesthetic quality of water the water is aesthetically not safe for drinking.
6. Alkalinity: The variation in the alkalinity of the reservoirs under study shows the varying trend. The alkalinity in natural waters is mainly due to the presence of

carbonates and bicarbonates in water and is affected by the $CO_2 - HCO_3 - CO_3$ balance. In the current study, the alkalinity in the reservoir Chapdoh is found highest and the variation in the alkalinity is quite low. This strongly points towards the geological contribution. The carbonaceous rocks in the region gets dissolved in the water and contribute to the alkalinity. Whereas the alkalinity variation in the reservoir Katepurna is slightly higher and may be a result of higher biological activities in the reservoir causing the disruption of $CO_2 - HCO_3 - CO_3$ balance and subsequently altering the alkalinity in water.

7. Considering the Parameters SAR, % Na and Boron which are significant with respect to the suitability of water for irrigation are well within the limits as per ICAR norms.

The above findings shows that although the water is quite suitable for irrigation purpose, as far as drinking water is concerned it is not desirable to use the water without any conventional treatment

RECOMMENDATIONS

1. Work should continue to identify other potential causes for water contamination as only identifying water quality problem does not preclude the possibility of other causes.
2. The people residing in nearby areas should be made aware of water quality to control domestic discharges.
3. As all the reservoirs are the major source of the public water supply, study of changes in water quality with special attention to drinking water treatment shall be carried out.
4. Land use and land coves studies of the watersheds should be carried out.
5. Water quality models with respect to the organic loading in the reservoir should be developed for assessing the probable future organic pollution.

ACKNOWLEDGEMENT

Authors wishes to acknowledge Hydrology Project Division, Nagpur for sharing the data collected. Thanks to the staff of the water quality lab level – II, Nagpur for extending full cooperation and assistance in field work and document preparation. Authors express sincere thanks to Chief Engineer, Hydrology Project and Superintending Engineer, Hydrology Project Circle for extending full support in the study and helpful comments to improve the manuscript.

REFERENCES

1. BIS IS : 10500:1991
2. Design Manual on water quality analysis by Delft Hydrolics and DHV Consultants.
3. Environmental Chemistry – Anil Kumar Dey
4. Introduction to Environmental Engineering and Science – Gilbert M. Masters

5. Somerville Reservoir Water Quality study – Melissa L. Mullins, Adam S. Whisenant. http:// www.tpwd.state.tx.us/publications/pwdpubs/media/pwd.rp_v3400_0067.pdf
6. U.S. Environmental Protection Agency – Monitoring and assessing water quality. http:// www.epa.gov/owow/monitoring/tech/
7. http:// ks.water.usgs.gov/Kansas/qw/olathe
8. ICAR standards
9. The Environment (Protection) act 1986. MoEF, GOI.