Characterization of raw water at Miraj WTP based on zeta potential and optimal coagulation strategies during monsoon period

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Abstract— Most water supply systems have evolved over the past decades into systems that can supply sufficient and safe water under the current conditions. Seasonal variation will affect these conditions, requiring a more rapid adaptation to new conditions. Rapid response is needed during events that cause an immediate threat to water quality. Water supply systems can be affected in various ways and through different causes. Surface water quality depends on a large number of physicochemical parameters. Surface water quality changes from season to season. Due to change in quality of surface water, necessary change in treatment is required in WTP. In this view an attempt is made in the present study to characterize of raw water at Miraj WTP based on zeta potential and related coagulation requirements are decided seasonally. The physicochemical parameters of raw water Miraj were studied and analyzed during period of September 2014 to November 2014.The analysis was done for the parameters like pH, Dissolved Oxygen (DO), Turbidity, Conductivity, Alkalinity, Total suspended solids, Zeta Potential, Chloride, Calcium, Magnesium and Hardness. The coagulant doses are decided by using three different types of coagulants such as alum, polyaluminium chloride and cationic polymer. The equipment Zeta Meter - 4, (U. S. A.) with computer interface and zeta potential software was used. Further the laboratory studies are carried out for improving aptness of influent water. Feasibility of techniques to improve quality of influent on field scale is also deliberated. The guidelines for operating are developed and use of zeta potential as a diagnostic operating parameter is presented.

Keywords- *Seasonal variations; physicochemical parameters; water quality; Krishna River*

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I. INTRODUCTION

Rivers constitute the main inland water body for domestic, industrial, and agricultural activities and often carry large municipal sewage, industrial wastewater discharges, and seasonal runoff from an agricultural field. (Rahaman S .2012).Higher water temperature will promote the growth of blue-green algae. Taste and odor compounds and cyanotoxins from these algae are of concern. Warmer water also facilitates microbiological growth in the rivers. Temperature increase can affect bacterial growth rate which is then associated with an increase in chlorine demand to maintain the level of chlorine constant. Chlorine decay in these conditions is then faster and if no action is taken, bacteria regrowth can happen within the water bulk. Increased precipitation and consequently runoff may lead to water quality problems such as higher Natural Organic Matter (NOM), higher number of microorganisms in the water and other contamination related problems. Decrease of precipitation in summer may affect water quality. Lower flow rates cause deposition leading to reduce raw water quality. Reduced raw water volumes, reduce dilution and increase drinking water quality risk.

Krishna basin extends over an area of 258948 km^2 which is nearly 8% of geographical area of country. Krishna River rises in the Western Ghats at an elevation of about 1337 m just north of Mahabaleshwar about 64 km from the Arabian Sea and flow for about 1400 km and outfalls into the Bay of Bengal. (Jadhav et al, 2006)

"Zeta potential" refers to the electric charge on ions surroundings suspended particulate matter, particularly the minute particles of 1 micron or smaller in size. These charges are, in nature, predominantly negative and therefore, cause repulsion between the particles. Larger particles tend to be dragged downward by gravity, but the electro kinetic charges prevent particles smaller than 1 micron in size from joining into groups of greater mass that would settle, owing to gravity. The value of these electro kinetic charges, in millivolts, is the zeta potential. The ZP of surface waters normally ranges from -15 to -25 mV. Theoretically, if this is reduced to near zero the repulsive forces are so reduced that the particle will tend to agglomerate and with continued agitation, will become large enough to settle.(Bean et al. 1963)

It is possible to determine the ZP of the particles in a particular system from the velocity at which these particles traverse a measured path in DC current at a specific voltage in the 50 to 500 volt range. This velocity is known as "electrophoretic mobility" and may be determined by observation of particle movement under a microscope, in an electrophoresis cell. One apparatus for determination of ZP through electrophoretic mobility utilizes a special plastic cell and a specially designed stereoscopic microscope .In general, measurements of the ZP of average particles can be determined and duplicated with an accuracy of ±1.0 mV in the -30 to -10 mV range;±2.0 mV in the -10 to + 30 range.

The jar tests determine the approximate doses and approximate pH zones for good results .When carefully run, these tests can be invaluable; however, with the present availability of the various polyelectrolytes such as cationic, anionic the need has become urgent for some measure that will assure that the application is the one that will produce the best possible result.

Fig.1 Zeta meter 4.0

II. Materials and Methods

A. Sampling:

Raw water was collected from Miraj water treatment plant. Samples were collected from Miraj plant at a frequency of twice in a week. The samples were collected in clean polythene cans.

B. Analysis:

Physicochemical parameters of raw water were measured twice in week frequency. Hydrogen ion concentration (pH), Dissolve Oxygen (DO), Total Suspended Solid (TSS).Conductivity was measured with the help of an electric conductivity meter. Turbidity of water was measured by using turbidity meter. Total Coliform was measured by MPN - Most Probable Number method in the laboratory.

Hardness, Chlorides, Calcium, Magnesium and Alkalinity were measured by titration methods in laboratory. Zeta potential of sample was measured with the help of the equipment Zeta Meter – 4.0 (U. S. A.) with computer interface and zeta potential software was used.

III. Results and Discussions

The parameters of raw water are measured from period September to November 2014. Results are summarized in Table I. (September),Table no. II.(October), Table III. (November).The jar test result of raw water samples from period September to November are summarized in Table IV. (September), Table V. (October), Table VI.(November) along with zeta potential of raw water, zeta potential at optimum dose and optimum dose of respective coagulant.

TABLE I. (SEPTEMBER)

Parameter	15-9-14	18-9-14	22-9-14	25-9-14
pH	7	6.8	7.2	7.5
Conductivity (micromho/cm)	560	530	620	490
Turbidity (NTU)	45	43	49	36
Hardness (mg/lit)	270	240	300	214
Chlorides (mg/lit)	36.51	34.21	38.28	21.27
Ca (mg/lit)	55.24	45.21	57.62	44
Mg (mg/lit)	52.24	47.58	59.29	41.48
TSS (mg/lit)	260	210	290	210
Z.P. (mV)	-30.22	-35.21	-32.14	-32.55
Alkalinity (mg/lit)	440	400	430	300
D.O. (mg/lit)	6.4	7.1	7.3	6.7
M.P.N. (Per 100 ml)	225	550	350	175

TABLE.II. (A) (OCTOBER)

Parameter	6-10-14	9-10-14	13-10-14	16-10-14
pH	7.1	7.4	6.7	6.8
Conductivity (micromho/cm)	453	480	898	490
Turbidity (NTU)	31	38	25	36
Hardness (mg/lit)	180	220	200	230
Chlorides (mg/lit)	26.58	32.24	19.49	31.68
Ca (mg/lit)	55	47.10	48.12	50
Mg (mg/lit)	30	42.21	37.88	43
TSS (mg/lit)	230	270	371	280
Z.P. (mV)	-34.80	-29.35	-31.40	-37.80
Alkalinity (mg/lit)	220	250	430	400
D.O. (mg/lit)	7.4	7.1	7.2	6.9
M.P.N. (Per 100 ml)	250	140	900	900

TABLE.II. (B) (OCTOBER)

Parameter	20-10-14	23-10-14	27-10-14	30-10-14
pH	7	6.8	7.4	7.1
Conductivity (micromho/cm)	510	435	530	46
Turbidity (NTU)	40	33	42	37
Hardness (mg/lit)	260	230	290	260
Chlorides (mg/lit)	34.20	21.30	37.50	28.2
Ca (mg/lit)	55.20	46.51	44.20	46.20
Mg (mg/lit)	50.02	44.89	41.20	57.09
TSS (mg/lit)	300	224	324	282
Z.P. (mV)	-33.24	-38.50	-31.20	-39.20
Alkalinity (mg/lit)	430	324	456	490
D.O. (mg/lit)	7.3	6.9	7.2	7
M.P.N. (Per 100 ml)	275	350	170	150

TABLE.IV. (SEPTEMBER)

Date		15-9-14	18-9-14	22-9-14	25-9-14
Alum	*Initial turbidity(NTU)*	45	43	49	36
	Final turbidity (NTU)	12.2	11.3	13.4	9.5
	Initial ZP of raw water(mV)	-30.22	-35.21	-31.40	-37.80
	ZP at optimum dose(mV)	-24.14	-27.14	-23.12	-22.10
	Optimum dose(mg/lit)	15	15	20	10
PAC	*Initial turbidity(NTU)*	45	43	49	36
	Final turbidity (NTU)	8.5	7.2	9.5	7.7
	Initial ZP of raw water(mV)	-30.22	-35.21	-31.40	-37.80
	ZP at optimum dose(mV)	-21.12	-22.14	-19.10	-18.20
	Optimum dose(mg/lit)	10	10	5	5
Cationic Polymer	*Initial turbidity(NTU)*	45	43	49	36
	Final turbidity (NTU)	5.5	5.3	6.7	5.7
	Initial ZP of raw water(mV)	-30.22	-35.21	-31.40	-37.80
	ZP at optimum dose(mV)	-19.24	-20.14	-17.20	-17.84
	Optimum dose(mg/lit)	15	15	25	25

TABLE.III. (NOVEMBER)

Parameter	3-11-14	6-11-14	10-11-14	13-11-14
pH	7.2	7.5	7.3	7.2
Conductivity (micromho/cm)	480	350	380	483
Turbidity (NTU)	31	35	38	42
Hardness (mg/lit)	240	300	340	265
Chlorides (mg/lit)	37.50	56	40.12	30.13
Ca (mg/lit)	47.10	62.10	58.20	57
Mg (mg/lit)	36.10	57.23	56.20	50
TSS (mg/lit)	230	237	247	340
Z.P. (mV)	-40.10	-39.97	-33.14	-35.8
Alkalinity (mg/lit)	416	300	377	280
D.O. (mg/lit)	6.9	8	7.5	7.8
M.P.N. (Per 100 ml)	140	80	110	95

TABLE.V (A) (OCTOBER)

Date		6-10-14	9-10-14	13-10-14	16-10-14
Alum	*Initial turbidity(NTU)*	31	38	25	36
	Final turbidity (NTU)	9.5	10.5	7.7	11.1
	Initial ZP of raw water(mV)	-34.80	-29.35	-31.40	-37.80
	ZP at optimum dose(mV)	-25.15	-21.10	-23.16	-25.30
	Optimum dose(mg/lit)	15	10	20	10
PAC	*Initial turbidity(NTU)*	31	38	25	36
	Final turbidity (NTU)	7.2	7.7	5.6	8.5
	Initial ZP of raw water(mV)	-34.80	-29.35	-31.40	-37.80
	ZP at optimum dose(mV)	-21.12	-18.20	-20.13	-22.10
	Optimum dose(mg/lit)	10	5	15	5
Cationic Polymer	*Initial turbidity(NTU)*	31	38	25	36
	Final turbidity (NTU)	5.2	5.5	2.2	5.2
	Initial ZP of raw water(mV)	-34.80	-29.35	-31.40	-37.80
	ZP at optimum dose(mV)	-19.25	-16.20	-17.30	-19.20
	Optimum dose(mg/lit)	15	25	30	25

TABLE.V (B) (OCTOBER)

Date		6-10-14	9-10-14	13-10-14	16-10-14
Alum	*Initial turbidity(NTU)*	40	33	42	37
	Final turbidity (NTU)	12.4	10.2	11.2	10.2
	Initial ZP of raw water(mV)	-33.24	-38.50	-31.20	-39.20
	ZP at optimum dose(mV)	-22.20	-27.50	-22.10	-29.10
	Optimum dose(mg/lit)	15	10	15	10
PAC	*Initial turbidity(NTU)*	40	33	42	37
	Final turbidity (NTU)	9.2	8.2	7.2	8.4
	Initial ZP of raw water(mV)	-33.24	-38.50	-31.20	-39.20
	ZP at optimum dose (mV)	-19.20	-20.12	-18.20	-24.10
	Optimum dose (mg/lit)	10	5	10	5
Cationic Polymer	*Initial turbidity(NTU)*	40	33	42	37
	Final turbidity (NTU)	6.5	5.6	5.7	4.3
	Initial ZP of raw water(mV)	-33.24	-38.50	-31.20	-39.20
	ZP at optimum dose(mV)	-16.50	-17.60	-16.20	-20.35
	Optimum dose(mg/lit)	15	25	15	25

TABLE.VI. (NOVEMBER)

Date		3-11-14	6-11-14	10-11-14	13-11-14
Alum	*Initial turbidity(NTU)*	40	33	44	37
	Final turbidity (NTU)	12.5	10.6	11.3	10.9
	Initial ZP of raw water(mV)	-33.24	-38.50	-31.20	-39.20
	ZP at optimum dose(mV)	-22.20	-27.50	-22.10	-29.10
	Optimum dose(mg/lit)	15	10	15	10
PAC	*Initial turbidity(NTU)*	40	33	44	37
	Final turbidity (NTU)	9.4	8.5	7.2	8.2
	Initial ZP of raw water(mV)	-33.24	-38.50	-31.20	-39.20
	ZP at optimum dose(mV)	-19.20	-20.12	-18.20	-24.10
	Optimum dose(mg/lit)	10	5	10	5
Cationic Polymer	*Initial turbidity(NTU)*	40	33	44	37
	Final turbidity (NTU)	6.2	5.1	5.8	4.2
	Initial ZP of raw water(mV)	-33.24	-38.50	-31.20	-39.20
	ZP at optimum dose(mV)	-16.50	-17.60	-16.20	-20.35
	Optimum dose(mg/lit)	15	25	15	25

From all the above samples tested during September to November 2014, we have found that sample no 3 of September 2014 has highest turbidity i.e. 49 NTU. Hence it is selected for analysis. Following is the graphical representation of all the samples of September 2014, to understand residual turbidity obtained after jar test with the help of three different coagulants such as Alum, Polyaluminium Chloride and Cationic Polymer.

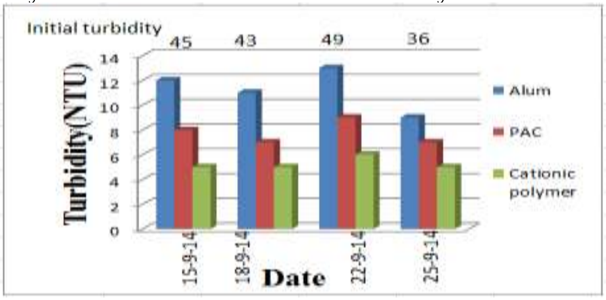

Fig.2 Date vs. Residual Turbidity (September)

TABLE VII.QUALITY WISE ANALYSIS:- SAMPLE NO 3 (SEPTEMBER 2014) TURBIDITY 49 NTU

Coagulant	Residual Turbidity(NTU)
Alum	13
PAC	9
Cationic Polymer	6

Here, we have considered quality is an important parameter. So, we have discussed the seasonal variation of raw water with respect to turbidity and zeta potential with Cationic Polymer as a coagulant.

TABLE VIII. VALUES OF INITIAL TURBIDITY AND CORRESPONDING ZETA POTENTIAL OF RAW WATER SAMPLES, SEPTEMBER 2014

Sample no.	Initial Turbidity(NTU)	Initial Zeta Potential(mV)
1	45	-30.22
2	43	-35.20
3	49	-31.40
4	36	-37.80

TABLE IX.RESULTS OF JAR TEST FOR INITIAL RAW WATER TURBIDITY OF SAMPLE NO.3 (SEPTEMBER 2014, INITIAL TURBIDITY 49 NTU)

Cationic polymer dose (mg/L)	Residual Turbidity (NTU)	Zeta Potential(mV)
5	10.14	-20.14
10	9.45	-19.90
15	8.64	-19.20
20	7.5	-18.98
25	6.7	-17.20

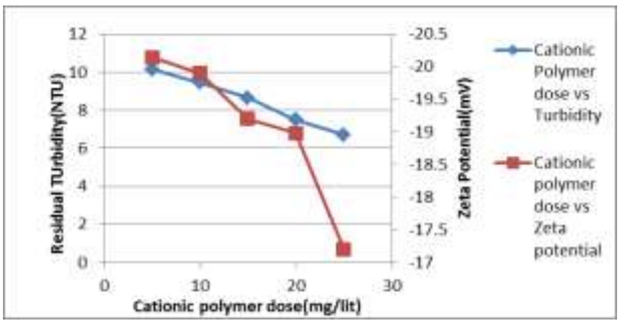

Fig. 3 Graph of Cationic polymer dose Vs. Zeta potential and Cationic polymer dose Vs. Residual turbidity

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TABLE X.VALUES OF INITIAL TURBIDITY AND CORRESPONDING ZETA POTENTIAL OF RAW WATER SAMPLES, OCTOBER 2014

Sample no.	Initial Turbidity(NTU)	Initial Zeta Potential(mV)
1	31	-34.80
2	38	-29.35
3	25	-31.40
4	36	-37.80
5	40	-33.24
6	33	-38.50
7	42	-31.20
8	37	-39.20

TABLE XI.RESULTS OF JAR TEST FOR INITIAL RAW WATER TURBIDITY OF SAMPLE NO. 7 (OCTOBER 2014, INITIAL TURBIDITY 42 NTU)

Cationic polymer dose (mg/L)	Residual Turbidity (NTU)	Zeta Potential(mV)
5	7.57	-20.40
10	6.11	-20.14
15	5.7	-19.20
20	6.76	-18.71
25	7.4	-18.20

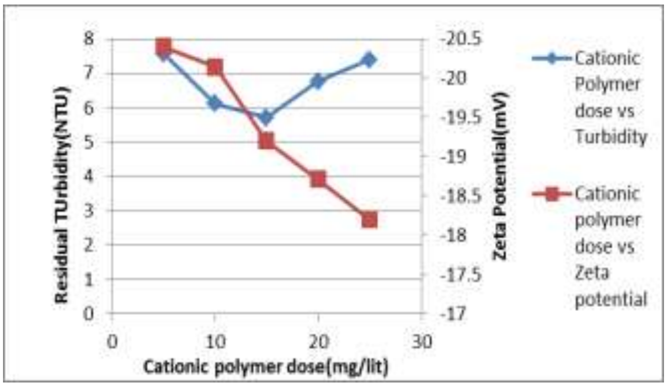

Fig.4. Graph of Cationic polymer dose Vs. Zeta potential and Cationic polymer dose Vs. Residual turbidity

TABLE XII.VALUES OF INITIAL TURBIDITY AND CORRESPONDING ZETA POTENTIAL OF RAW WATER SAMPLES, NOVEMBER 2014

Sample no.	Initial Turbidity(NTU)	Initial Zeta Potential(mV)
1	40	-33.24
2	33	-38.50
3	44	-31.20
4	37	-39.20

TABLE XIII RESULTS OF JAR TEST FOR INITIAL RAW WATER TURBIDITY OF SAMPLE NO 3 (NOVEMBER 2014, INITIAL TURBIDITY 44 NTU)

Cationic polymer dose (mg/L)	Residual Turbidity (NTU)	Zeta Potential(mV)
5	8.75	-19.90
10	7.14	-19.10
15	5.8	-18.88
20	6.80	-18.13
25	7.48	-17.50

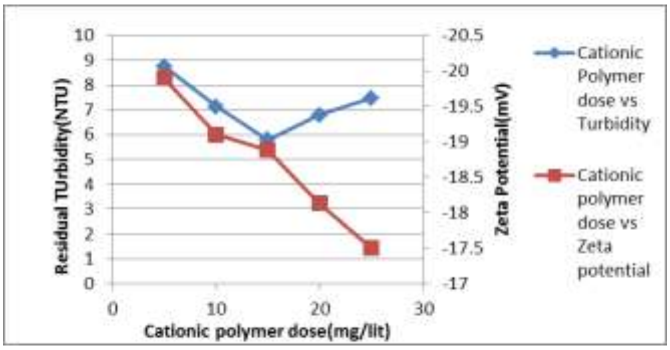

Fig.5 Graph of Cationic polymer dose Vs. Zeta potential and Cationic polymer dose Vs. Residual turbidity

Initial raw water turbidity of sample no 3, September 2014 was 49 NTU, optimum cationic polymer dose obtained was 25 mg/l by jar test. When 25 mg/l dose was given, residual turbidity of 6.7 NTU was obtained. Corresponding zeta potential of suspension with 25 mg/l cationic polymer dose was obtained as -17.20 mV (Fig 3). It was also observed that as the dosage of coagulant goes on increasing, the value of zeta potential travels towards zero.

Initial raw water turbidity of sample no 7, October 2014 was 42 NTU, optimum cationic polymer dose obtained was 15 mg/l by jar test. When 15 mg/l dose was given, residual turbidity of 5.7 NTU was obtained. Corresponding zeta potential of suspension with 15 mg/l alum dose was obtained as -19.20 mV (Fig 4).

Initial raw water turbidity of sample no 3, November 2014 was 44 NTU, optimum alum dose obtained was 15 mg/l by jar test. Residual turbidity of 5.8 NTU was obtained when 15 mg/l dose was given. Corresponding zeta potential of suspension with 15 mg/l alum dose was obtained as -18.88 mV (Fig 5).

IV. CONCLUSION:

It was observed that turbidity ranges from 25 to 49 NTU from September to November 2014.Cationic polymer was efficient coagulant to obtain less residual turbidity as compared to other two coagulants. And also, zeta potential of raw water was significantly reduced by using cationic polymer as a coagulant as compared to other two coagulants.

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REFERENCES

[1] Ashraff M and Mukundan M. (2007), "Seasonal variations in water quality of four stations in Periyar river basins", Journal of Environmental Science and Engg.Vol.49, No.2, pg.no.127-132.

[2] Bamakanta G., Sunakar P., Tripathy S. and Tripathy P. (2013), " Seasonal variation of Nagavali river water quality at the vicinity of paper mill near Jayakapur, Odisha, India", International Research Journal of Environment Sciences, Vol.2, No.5,pg.no.46-52.

[3] Bean E.J., Campbell S.J. and Anspach F.R. (1963), "Zeta potential measurements in the control of coagulation chemical doses", Journal of American Water Works Association.

[4] Hasan A., Thacker N. and Bassin J.(2010), "Seasonal variation of trihalomethane formation potential in treated water supplies of Delhi city", Journal of Environmental Science and Engg.Vol.52, No.3,pg.no.235-240.

[5] Jadhav S., Kanase D., Jawale R. and Jadhav M. (2006), "Physicochemical assessment of Krishna river at Karad, Satara district (Maharashtra).

[6] Mahadev J., Srikantswami S., Gholami S. and Ahmad S. (2010), "Assessment of environmental variables in Cauvery river and its Tributaries", Journal of Environmental Science and Engg.Vol.52, No.4, pg.no.307-310.

[7] Manjappa S and Nail V. (2004), "Physicochemical properties of Malaprabha river", Journal of Environmental Science and Engg.Vol.49, No.1, pg.no.1-6

[8] Pokale W., Thakre J. and Warhate S. (2010), "Water quality status of Pench reservoir", Journal of Environmental Science and Engg.Vol.52, No.3, pg.no.255-258.

[9] Raveen R and Daniel D. (2006), "Spatial changes in water quality of urban lakes in Chennai - a case study", Journal of Environmental Science and Engg.Vol.52, No.3, pg.no.259-264.

[10] Rehaman S. (2012), "Variation in water qualities in Ganga and Brahmaputra River", Department of Environmental Sciences, Jahangirnagar University, Savar, Dhaka-1342