Impact of pollution on potable ground water in rural area of eastern Pune metropolitan region

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***Abstract*—Potable ground water quality is at risk due to contamination by pollution, sewage, industrial effluent along the nearby areas of Mula-Muthariver banks in eastern metropolitan region of Pune. Physicochemical and microbiological assessment of some polluted river stream and nearby bore well sites to understand the impact of water contamination in drinking water quality was done. The physicochemical properties showed increase in hardness, elevated TDS and conductivity for bore well samples. TSS and turbidity levels were increased for river water. Microbiological studies shows high contamination of river samples due to high titers of total coliforms and total *E coli* colony counts. While the bore well samples showed random presence of coliforms and *E coli*. This indicate necessity to pre-treat the hard water samples of bore well and further disinfect water before using for drinking purpose.**

***IndexTerms*—Mula-Mutha, ground water, contamination, physicochemical assessment, potable water**

I. INTRODUCTION

AllGroundwater is one of the purest form of water and a permanent and reliable source of water for majority of world's population especially in rural area. It constitutes about 30% of the world's total fresh water and 99% of its total stock of liquid fresh water [1]. Mula-Mutha River and bore wells based on bank of river area a major source of water for drinking, domestic and agricultural use in people of the eastern Pune metropolitan area. Some 15% of world's crop land is irrigated by groundwater. The present irrigated area in India is 60 million hectares (Mha) of which about 40% is from ground water [2].

The consequences of urbanization and industrialization had lead to spoiled water quality. The addition of various kinds of pollutants and nutrients through the sewage, industrial effluents, agricultural runoff etc. into the water bodies of Mula-Mutha River brings about a series of changes in the physicochemical and biological characteristics of water [3, 4]. In our primary investigation we have studied few physicochemical and microbial parameters (pH, COD, hardness, TSS, MPN) of water sample collected from Mula-Mutha river stream and bore wells located on bank of river to understand pollution status in pre and post monsoon period in eastern part of Pune metropolitan area. The results revealed that water from above sources is under deteriorating condition since some physicochemical parameters were above the standard limits with presence of high count of certain types of bacteria which are considered as water pollution indicators.

With reference to our primary reports we had selected various sites in eastern part of Pune metropolitan area from Mula-Mutha River where pollution is there and bore wells in surrounding regions where the pollution is associated for our extensive study. The study involved assessment of water quality at these selected locations in monsoon and post monsoon period for monitoring the potability of water. The study involved determination of the physical, chemical, microbiological parameters of water samples like pH, chemical oxygen demand (COD), turbidity, total dissolved solids (TDS), total hardness (TH), total suspended solids (TSS), conductivity, dissolved oxygen (DO), total sulphates, total chlorides, total phosphates, temperature, total Coliform and total E. coli.

II. MATERIALS

The following were the sampling stations selected for the water quality assessment of Mula-Muthariver and bore-well sites in eastern zone of Pune metropolitan area.

Table 1 Water sampling stations

Name of sampling station (River)	Name of sampling station (Bore well)
A Manjari bk. Bridge	**B**Manjarai-nagarbk (Right bank)
ETheur (near ChintamaniVidyamandir)	**C**Manjarikhurd (Left bank)
J River Water sample, Ashtapur	**D**KolawadiSasthe (Left bank)
	FTheur (near ChintamaniVidyamandir) (Right bank)
	GBhapkar-mala, Manjari Bk. (Right bank)
	H MAEER's MIT Institute of Design, Loni (Right bank)
	IAshtapur (Left bank)

Out of above selected sampling stations, A, B, C, D, E and F sampling stations were visited during primary study and water samples were collected to study the physicochemical and biological parameters of water during post monsoon 2016 and pre-monsoon season in 2017. Water samples were collected in sterilized glass bottles. Date, time of collection and source of water sampling locations of the area were recorded properly. Sampling locations of bore wells were around approximately 1 to 1.5 km from the banks of Mula-Muthariver. From each of the sampling site, 2L water samples were collected for physicochemical analysis.

III. METHODOLOGY

Standard methods were used for the determination of the physicochemical characteristics of water. For biological analysis, water samples were tested for total coliform counts, E. coli counts.

3.1 Physicochemical analysis [5, 6, 7]

Physicochemical parameters of water samples were studied as per procedure mentioned in parts of IS 3025 section ofEnvironmental Protection and Waste Management (CHD 32) of Bureau of Indian Standards (BIS). pH, total suspended solids (TSS), total hardness (TH), total dissolved solids (TDS), and conductivity, total sulphates, total chlorides, temperature were determined.

Chemical Oxygen Demand (COD), Dissolved oxygen (DO), total phosphates (PO_4) was determined as per procedure mentioned in American Public Health Association 40CFR.

3.2 Biological analysis

MPN analysis and petrifilm are commonly used methods for determination of potability of water and to assess the sewage contamination and other biological contamination of water that render the water unsafe for drinking and risk for diseases.

3.2.1 MPN analysis [8]

This method is used to detect total coliform count, faecal coliform count and *E. coli* count. This comes under MTFT (multiple tube fermentation technique) as suggested by WHO. This method is based on the statistical approach of probability (Mc-cready's probability table).

3.2.2 Petrifilm method [9, 10]

Total Coliform and *E coli* in water was determined by Petrifim method. Petri film plates are widely used because of their cost-effectiveness, simplicity, convenience, and ease of use. 1 ml of water sample was added to petri film and incubated for 48 hours at 37ºC. Pink colonies for total Coliform and Blue for *E. coli* were counted and calculation done to represent colonies per ml of river water.

IV. RESULTS AND DISCUSSION

The primary study of water samples of sites of river A and E while for bore well sites B, C, D and F were carried out during pre and post monsoon time periods. Based on these studies the sites were finalized and more sites were added for extensive studies. The extensive study was carried for drinking water sites i.e. bore well sites (B, C, D, F, G, H, I) during monsoon 2018 and winter 2018 season times. While the extensive study was carried out for river sites (A, E, J) during monsoon for purpose of assessment of quality of water that flows through surrounding neighborhood from where drinking water is collected from bore well.

Table 2 Primary Physicochemical analysis of Mula-Mutha river water samples

Tests	Sampling stations of river			
	A$	E$	A #	E #
pH	6.90	7.73	6.35	6.98
TDS (mg/L)	498	898	---	---
COD (mg/L)	49	75	40	88
TSS (mg/L)	184	410	200	400
Total hardness (mg/L of $CaCO_3$)	187.9	292.1	201.6	307.2

$ - Pre monsoon samples analysis # post monsoon samples analysis

Table 3 Primary Physicochemical analysis of bore well water samples

Tests	Sampling stations of bore well							
	B$	C$	D$	F$	B#	C#	D#	F#
pH	7.76	7.0	7.90	7.20	6.77	6.76	7.2	7.16
TDS (mg/L)	201	801	809	843	---	---	---	---
COD (mg/L)	62	18	74	65	80	16	112	128
Total hardness (mg/L of $CaCO_3$)	384.2	346.0	369.3	340.6	259.2	336.0	364.8	344.6

$ - Pre monsoon samples analysis # post monsoon samples analysis

Table 4 Physicochemical and biological properties of water samples of river sites

S. No	Parameters	A	E	J
1	pH	7.12	7.20	7.16
2	COD (mg/L)	20.0	27.6	16.0
3	TSS (mg/L)	204.0	12.0	321.0
4	Turbidity (NTU)	11.0	4.0	11.0
5	TH (as $CaCO_3$) mg/L	164.0	144.0	164.0
6	TDS (mg/L)	230.0	240.0	240.0
7	Conductivity at 25^0 C	420.0	440.0	420.0
8	DO (mg/L)	7.2	2.8	7.2
9	Total $S0_4$ (mg/L)	39.51	67.50	52.68

10	Total Cl (mg/L)	61.15	60.26	54.06
11	Total PO_4 (mg/L)	0.067	0.070	0.073
12	Temperature ^{0}C	24.9	24.5	24.6
13	Coliform CFU/ml	TNTC	260	156
14	E.Coli CFU/ml	TNTC	64	Nil

Table 5 Physicochemical and biological properties of water samples of bore well sites (Monsoon 2018 samples)

S.No	Parameters	B	C	D	F	G	H	I
1	pH	7.56	7.65	7.34	7.40	7.34	7.77	6.89
2	COD (mg/L)	28.0	18.4	30.0	9.2	64.4	25.0	19.0
3	TSS (mg/L)	32.0	12.0	9.0	45.0	8.0	15.0	11.0
4	Turbidity (NTU)	1.0	1.0	1.0	3.0	Nil	1.0	1.0
5	TH (as $CaCO_3$) mg/L	280.0	424.0	344.0	444.0	436.0	572.0	168.0
6	TDS (mg/L)	310.0	520.0	550.0	510.0	610.0	780.0	310.0
7	Conductivity at 25 ^{0}C	560.0	920.0	980.0	920.0	1090.0	1390.0	550.0
8	DO (mg/L)	4.8	3.9	4.4	7.5	3.2	3.3	3.5
9	Total $S0_4$ (mg/L)	84.78	65.85	96.31	97.13	89.72	155.58	93.02
10	Total Cl (mg/L)	62.92	138.25	121.41	119.64	155.09	149.77	120.53
11	Total PO_4 (mg/L)	0.062	0.068	0.079	0.055	0.067	0.078	0.032
12	Temperature ^{0}C	25.9	25.3	25.2	25.2	25.4	25.2	24.8
13	Coliform CFU/ml	Nil	06	Nil	03	166	09	Nil
14	E.Coli CFU/ml	Nil		Nil	Nil	94	Nil	Nil

Table 6 Physicochemical and biological properties of water samples of bore well sites (Winter 2018 samples)

S.No	Parameters	B	C	D	F	G	H	I
1	pH	7.93	7.92	7.64	8.05	7.35	7.91	8.42
2	COD (mg/L)	26.4	17.6	44.0	8.8	26.4	35.2	13.2
3	TSS (mg/L)	9.0	8.0	11.0	9.0	8.0	10.0	11.0
4	Turbidity (NTU)	1.0	1.0	1.0	1.0	2.0	1.0	1.0
5	TH (as $CaCO_3$) mg/L	320.0	356.0	464.0	304.0	524.0	552.0	128.0
6	TDS (mg/L)	402.0	568.0	705.0	616.0	640.0	920.0	380.0
7	Conductivity at 25 ^{0}C	718	1014	1258	1100	1142	1642	678
8	DO (mg/L)	6.6	7.0	6.8	7.0	6.3	6.4	6.8
9	Total $S0_4$ (mg/L)	39.51	51.86	61.74	55.97	65.85	84.78	40.33
10	Total Cl (mg/L)	79.97	23.68	144.0	109.96	149.95	164.94	69.97
11	Total PO_4 (mg/L)	0.067	0.070	0.073	0.060	0.064	0.080	Nil
12	Temperature ^{0}C	25.4	24	23	25	24	25	23
13	Coliform CFU/ml	1	3	3	6	4	Nil	1
14	E.Coli CFU/ml	Nil	2	Nil	Nil	2	Nil	Nil

4.1 pH

Primary study carried out during pre and post monsoon season shows pH values for borewell samples within normal range of 7.0 to 8.5 recommended by WHO, except for the sample B and C collected during post monsoon (Table 3). The river samples show values lower than the required norms except for pre monsoon of sample E (Table 2). All the water samples collected from sampling stations A and E of Mula-Muthariver showed pH in between 6.35-7.73 (Table 2) and pH value of bore well water collected from four different sites along the bank of Mula-Mutha river varied in between 6.76-7.90 (Table 3).

Repeated analysis of water samples of previous sites and new sites of river (A, E, J) and bore well (B, C, D, F, G, H) showed pH values within normal range except bore well site I . Bore well samples were analyzed during monsoon and winter 2018 (Table 4, 5, 6). The study shows that water could be classified as suitable for drinking purpose only for pH perspectives. However variations of pH are due to the varied atmospheric condition and other biological activities at different sites.

4.2 TDS

The concentration of total dissolved solids (TDS) in natural water is usually less than 500 mg/L. TDS of Mula-Mutha river water sample was 498 and 898 mg/L respectively at stations A and E (Table 2). Water samples collected from bore wells exhibited

TDS in between 201-843 mg/L (Table 3). Except for sample B, rest of samples showed higher TDS values and is not fit for drinking purpose in primary study and indicate variable quantity of dissolved inorganic salts.

Repeat studies during monsoon and winter season showed total dissolved solids (TDS) in normal range for river water sample (Table 4) and elevated for bore well samples but acceptable for sample B and I, while sample C, D, F, G, H have higher TDS values than acceptable limit (Table 5, 6).

4.3 COD

COD analysis used to measure the amount of organic compounds in water in determination water quality. Initial studies show that all the water samples of river have high COD contents. It ranges from 49 to 88 mg/L (Table 2). While bore well water samples collected from different sites exhibited 62, 18, 74 and 65 mg/L for pre monsoon and 80, 16, 112 and 128 mg/L for post monsoon respectively to B, C, D and F sites (Table 3). This increased COD value is linked with heavy pollution from paper industries, domestic sewage and industrial effluents on the bank of Mula-Mutha River.

Repeat study for bore well water during monsoon and winter 2018 show values within COD limits for samples B, C, D, F, H, I, except for sample G during monsoon season (Table 5, 6). This indicates lesser organic related oxygen demand at these sites.

4.4 Total hardness

Hardness is measured in terms of equivalent quantity of $CaCO_3$. Total hardness (TH) of water samples collected from Mula-Mutha River showed 187.9 and 307.2 mg/L for sites A and E during pre and post monsoon (Table 2). While, it was in range of 259.2 to 384.2 mg/L for bore well water sampling sites B, C, D and F (Table 3). These results indicated that water samples collected from river showed hardness within desirable range. But almost all bore well water samples have hardness greater that 300mg/l. This high hardness during pre monsoon season (summer season) may be attributed to low ground water level and high rates of evaporation. Therefore all water from bore well is considered as a very hard during pre monsoon season and required processing before use.

The repeat studies of bore well samples during monsoon and winter 2018 time points showed hardness in range of 128 to 572 mg/L. Except for sample I during both monsoon and winter and sample B during monsoon (Table 5, 6), all the rest of the samples show higher hardness rendering it less suitable for drinking. The monsoon analysis of river samples shows hardness well within normal range (Table 4).

4.5 TSS and turbidity

Total Suspended Solids (TSS) and turbidity for river water samples are higher compared to the bore well samples indicating less clarity of river water compared to bore well water (Table 4, 5, 6). TSS studied in monsoon and winter is in range of 8 to 45 mg/L and turbidity mostly 1 NTU and in range of 0-3 (Table 5, 6) for bore well samples. The river water samples showed TSS values in range of 184-410 mg/L in all tests (Table 2, 4) except for sample E studied during monsoon period and turbidity showed in range of 4-11 NTU (Table 4).

These solids are due to anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae. Organic particles from decomposing materials can also contribute to the TSS concentration. As algae, plants and animals decay, the decomposition process allows small organic particles to break away and enter the water column as suspended solids. Even chemical precipitates are considered a form of suspended solids. Total suspended solids are a significant factor in observing water clarity. The more solids present in the water, the less clear the water will be.

4.6 DO

Dissolved Oxygen (DO) levels are above 5mg/l acceptable for drinking water. It indicates prevention of death and decay in water. Except during monsoon samples of bore wells (Table 4, 5, 6)

4.8 Total sulphates and chlorides

Sulphate and chloride levels are well below the toxic level for both river and bore well samples studied (Table 4, 5, 6).

4.9 Total phosphates

Total phosphates are also within acceptable range for both river and bore well samples studied (Table 4, 5, 6)

4.10 Conductivity

Conductivity is in lower range for river water samples compared to bore well samples. The bore well sample B and I show lower values while other bore well samples show elevated values but within acceptable limit (Table 4, 5, 6). These results are synonymous with the TDS and hardness of bore well water indicating ionic concentration in water.

4.11 MPN test

Table 7 MPN Test Results (Using Mc-cready's Table)

Sample Type	Set I (10ml)	Set II (1ml)	Set III (0.1ml)	MPN of coli forms (per 100ml water)
A	5	5	5	1800+
B	5	5	4	1600
C	5	4	5	425
D	5	4	5	425
E	5	5	5	1800+
F	5	5	5	1800+

Samples A, B, E & F showed high count of Coliform. Samples C & D showed low Coliform count.

The MPN study was carried out during post monsoon2016 during primary studies. Study show that samples A, B, E & F had high MPN counts suggestive of fecal (Sewage) contamination. Therefore the water is not safe for drinking purpose and it is necessary to treat such water.

4.12 Total Coliform and E coli

River water showed definite presence of total Coliform and *E coli* bacteria indicating harmful for drinking. Bore well samples show random presence but in low titre when checked in rainy season and winter season. Hence, it showed necessity for disinfection for safe use of drinking (Table 4, 5, 6).

V. CONCLUSION

The present study was undertaken to assess physicochemical parameters of water samples collected in pre-monsoon, monsoon and post monsoon seasons, from water bodies of Mula-Mutha and bore wells from different locations on bank of river in eastern part of Pune metropolitan region. Results showed that pH of all water samples were in permissible range. But most of the physicochemical parameters studied are out of permissible limits standardized for drinking water. The physicochemical properties showed increase in hardness, elevated TDS and conductivity for bore well samples. TSS levels were increased for river water. Sulphates, chlorides and phosphates were in normal range. pH is within range and conductivity were slightly elevated for bore well samples than river. There was definite presence of total coliform and *E coli* in river water and random presences of total coliform and *E coli* in bore well samples.

Therefore our study indicated that water from Mula-Mutha River and bore well are not suitable for drinking and domestic use and required processing before use.

VI. REFERENCES

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