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CHARACTERIZATION OF RURAL DRINKING WATER SOURCES IN BHIWANI DISTRICT, HARYANA: A CASE STUDY

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Abstract: **Rural India has more than 700 million people residing in about 1.42 million habitations spread over 1.5 diverse ecological regions. Meeting the drinking water needs of such a large population can be a difficult task.In rural India, village ponds and groundwater well have been playing very vital role in socio, cultural, economic and environment development. These Ponds are the common property of Indian villages and support the livelihoods of the marginalized community in rural, urban, coastal and tribal areas of India. Due to contaminations of these drinking water sources in villages, around 38 million Indians are affected by waterborne diseases annually; 1.6 million children are estimated to die of Diarrhea alone. Indians are at risk due to excess fluoride and 10 million due to excess arsenic in groundwater. Hardness and Chloride are also deteriorating the water supply lines and structures along with few reported health issues like hypertension and bone disease in rural India. This is an effort to characterize the drinking water quality available in the village water sources like ponds and deep wells. A case study of village & P O Kharak Kalan District Bhiwani, Haryana.**

Keywords: **Contamination, Drinking Water Quality, Chloride, waterborne diseases.**

I. INTRODUCTION

The presence of several contaminants in the source of drinking water in rural area of India is of major concern due to their toxicity to many life forms. Groundwater is the chief source of drinking water in India and this is only 0.61% of the total available water on Earth. It is reported that only 4% of world's freshwater resources are available in India while India inhabitants 14% of the world population. This shows scarcity of water in India. Article 47 of Indian Constitution rests the responsibility of providing safe drinking water to the public with the State Governments. According to one estimate 64% of rural population and 91% of the urban people have access to safe drinking water. The availability of water to India is almost fixed due to limited resources. But, with growing Indian population the per capita availability of water is steadily reducing; and when this drops below 1700m3/ person/ year, India will be water stressed. Due to over exploration of groundwater in rural area for drinking as well as agriculture purpose, the concentration of the different contaminants are increasing day by day. Water pollution is one of the major and most urgent problems of the modern world. Many pollutants and their breakdown products are harmful to life and property. Rural water sources have different type of pollution sources compare to urban scenario. Most of the rural area in the country is being supplied with the untreated ground as well as surface water for drinking. This water is not safe being having physical, chemical and biological contaminations. This report is based on different sample collection from a village in Haryana and on site sample testing with Jal Tara water quality Kit.

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II. RAW WATER SOURCE IN RURAL AREA OF HARYANA

The rural water supply in India is based on the available water sources like ponds & wells (Deep or Tube wells). These water sources have different water characteristics with reference to the contamination in the water. The surface water sources have high contamination as compare to the deep well water sources. There are no arrangements of water treatment plants in most of the village in the Haryana state. Few villages situated near the Rajasthan border are having more critical situation of lack of pure drinking water. It is also difficult for all the villagers to have the portable drinking water purifier to treat their water as they are not so educated to know the threats and importance of drinking water qualities. Ponds of the village are continuously being polluted by the villager's activity of washing clothes, bathing of self & their animals etc. The same water is the sources of recharge of adjacent deep wells.

2.1 Source of Contaminants

All natural waters contain different contaminants. Their concentrations vary considerably according to the source content of any given area. In small amounts they are not significant. In large concentrations they present problems. Excessive concentrations of either, of course, can make water unpleasant to drink.

- Rocks containing different natural resources;
- Agricultural runoff;
- Wastewater from small scale industries ; and
- Effluent wastewater from wastewater treatment plants.
- Contamination by anthropogenic sources.

SR. NO	PARAMETERS	STANDARD VALUE
1	PH	6.5-8
2	TEMPERATURE (°C)	-
3	COLI FORM	ABSCENT
4	FLUORIDE	1-1.5
5	DISSOLVE OXYGEN	>3 MG/L
6	RESIDUAL CHLORINE	0.2 MG/L
7	PHOSPHORUS	10-30 MICRO G/L
8	NITRATE	45
9	IRON	0.3-1
10	HARDNESS	300-600 PPM
11	CHLORIDE	250-1000
12	AMMONIA	<1.5 MG/L
13	TURBIDITY (NTU)	5-10 NTU
14	TDS	<400

III. MATERIAL AND METHODS

3.1 Study Area

Samples of well water as well as pond water were collected and tested in Village Kharak Kalan, District Bhiwani, and Haryana. Total Population of the village is 20,000. This village is located 100KM North West to Delhi.

Bhiwani District lies in South-Waster n part of Haryana state covering an area of 5140 sq.km. There is no perennial river passing through the district. Physiographical the district consists of flat and level plain interrupted from place to place by cluster s of sand dunes, isolated hillocks and rocky ridges. A few isolated rocky ridges elevated sharply from the plain occur in the south central portion or the district. Dohan River is the only ephemeral al stream in the area and flows in direct response to precipitation. Bhiwani district ranks 3rd in Haryana with a population of 14,25,022.The density of population is 298 per Sq.Km. The literacy rate in the district is around 73%. 67% of the population lives in Rural area and the remaining 33% of the population lives in Urban area. Out of 444 villages 437 are inhabited and 7 are less inhabited.

The climate of Bhiwani district can be classified as tropical steppe, semi-arid and hot which is mainly dry with very hot summer and cold winter except during monsoon season when moist air of oceanic origin penetrate into the district. There are four seasons in a year. The hot weather season starts from mid March to last week of the June followed by the south-west monsoon which lasts up to September. The transition period from September to October forms the post-monsoon season. The winter season starts late in November and remains up to first week of March. The normal annual rainfall of the district is 420 m which is unevenly distributed over the area 22 days. The south west monsoon sets in from last week of June and withdraws in end of September, contributed about 85% of annual rainfall. July and August are the wettest months. Rest 15% rainfall is received during non-monsoon period in the wake of western disturbances and thunder storms. Generally rainfall in the district increases from southwest to northeast.

3.2 Materials and Reagents

The water was taken from the pond as well as from the well in the village. This water is being used by the villagers and the animals. The color of the water is green with high level of turbidity especially in the pond water. The onsite sampling and testing of the drinking water was done with the help of Jal Tara Water testing kit approved by Shriram Testing Lab, Delhi. This kit can test 14 parameters of drinking water quality. This kit contains all the required chemicals which are used for testing all 14 parameters. One parameter can be determined hundred times by one set of chemical in this kit.

Table 1. List of parameter checked by Kit

Sr. no	Parameters	Standard value
1	PH	6.5-8
2	Temperature(^{o}C)	-
3	Coli form	Abscent
4	Fluoride	1-1.5
5	Dissolve Oxygen	>3 mg/l
6	ResidualChlorine	0.2 mg/l
7	Phosphorus	10-30 micro g/l
8	Nitrate	45
9	Iron	0.3-1
10	Hardness	300-600 ppm
11	Chloride	250-1000
12	Ammonia	<1.5 mg/l
13	Turbidity (NTU)	5-10 NTU
14	TDS	<400

Figure 1

3.3 Sample Collection:

Aseptic condition was adopted for the collection of different sample. All about 24 samples were collected, 12 each from well water and pond water respectively. The period of collection of sample was decided from January 2014 to June 2014. Two samples were taken from one source in a month time. The period of January to June is including almost both the extreme weathers in India. The major seasonal variation in the contamination maybe observed during this period.

IV. RESULTS AND DISCUSSION

4.1 Onsite Testing Of Water

As the onsite water testing were done in the village Kharakkalan, District. Bhiwani, Haryana by using Jal Tara Water testing Kit. The sample was taken twice in a month and this study was carried out for the water sample from January 2014 to June 2014 i.e. for six months. The observation reported after the field test of the water sample by the Jaltara Kit as shown in table 2 & 3. It shows 12 samples from each source with 14 parameters checks

SR. NO	PARAMETERS	STANDARD VALUE	TABLE 2. OBSERVED VALUE FROM DEEP WELL											
			JANUARY 2014		FEBRUARY 2014		MARCH 2014		APRIL 2014		MAY 2014		JUNE 2014	
			SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	SAMPLE 7	SAMPLE 8	SAMPLE 9	SAMPLE 10	SAMPLE 11	SAMPLE 12
1	PH	6.5-8	8	8	8	8.5	8.5	8.5	8	8	8	8	8	8
2	TEMPERATURE (°C)	-	21	21	21	21	21.5	22	22	23	23	22	22	22
3	COLI FORM	ABSCENT	A	A	A	A	A	A	A	A	A	A	A	A
4	FLUORIDE	1-1.5	1.6	1.5	1.2	1.2	1.2	1.2	1	1	.9	.9	1	1
5	DISSOLVE OXYGEN	>3 MG/L	10	9	11	10	10	10	10	11	11	11	10	10
6	RESIDUAL CHLORINE	0.2 MG/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	PHOSPHORUS	10-30 MICRO G/L	100	100	108	114	109	115	116	100	102	105	112	108
8	NITRATE	45	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
9	IRON	0.3-1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
10	HARDNESS	300-600 PPM	1100	1100	1130	1135	1147	1178	1127	1105	1173	1158	1155	1160
11	CHLORIDE	250-1000	1129	1140	1140	1204	1140	1148	1185	1168	1287	1297	1150	1174
12	AMMONIA	<1.5 MG/L	1	1	1	1	1	1	1	1	1	1	1	1
13	TURBIDITY (NTU)	5-10 NTU	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
14	TDS	<400	260	280	220	220	220	230	220	200	230	260	250	230

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SR. NO	PARAMETERS	STANDARD VALUE	TABLE 3. OBSERVED VALUE FROM POND											
			JANUARY 2014		FEBRUARY 2014		MARCH 2014		APRIL 2014		MAY 2014		JUNE 2014	
			SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	SAMPLE 6	SAMPLE 7	SAMPLE 8	SAMPLE 9	SAMPLE 10	SAMPLE 11	SAMPLE 12
1	PH	6.5-8	10	9	9	9	9	9	9	9	9	10	10	9
2	TEMPERATURE (℃)	-	22	23	22	22	23	23	25	25	25	25	26	26
3	COLI FORM	ABSCENT	P	P	P	P	P	P	P	P	P	P	P	P
4	FLUORIDE	1-1.5	1.6	1.5	1.2	1.2	1.2	1.2	1	1	.9	.9	1	1
5	DISSOLVE OXYGEN	>3 MG/L	0.4	0.3	0.5	0.5	0.8	0.6	0.6	0.8	0.8	0.6	0.6	0.6
6	RESIDUAL CHLORINE	0.2 MG/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	PHOSPHORUS	10-30 MICRO G/L	100	104	105	120	120	120	110	100	105	105	110	110
8	NITRATE	45	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
9	IRON	0.3-1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
10	HARDNESS	300-600 PPM	1120	1100	1170	1185	1247	1168	1147	1205	1153	1148	1135	1230
11	CHLORIDE	250-1000	1120	1100	1150	1200	1240	1248	1285	1268	1287	1297	1250	1274
12	AMMONIA	<1.5 MG/L	3	1	2	1	3	2	3	2	2	2	1	1
13	TURBIDITY (NTU)	5-10 NTU	60	60	65	65	60	60	65	60	60	55	55	60
14	TDS	<400	460	480	390	420	420	430	420	430	430	460	450	450

During this study the atmospheric temperature varied from 180c to 410c but it was seen that there was a very little temperature variation in the water. The color of the well water was transparent but the color of the pond water was greenish. In the pond water there was no aquatic life seen. Only bacterial presence was seen through the bacteria test. A high pH was noticed in the pond water. The first reason may be. When the water is allowed to sit in the open air, a considerable amount of the dissolved carbon dioxide dissipates. Correspondingly, the water's pH rises. The second cause of pH rise in ponds is algae. This pond water is green and will be more after period of time. That green coloring is plank tonic algae. Algae, like all green plants, converts sunlight to food via photosynthesis. As part of that process, the algae remove carbon dioxide from the water and produce oxygen. Again, removing carbon dioxide from the water produces a rise in pH. The pH of the deep well was also high but was less than pH range of pond water.

The coliform bacteria was present in the pond water but the same was absent in the well water. Coliform bacteria are a commonly used bacterial indicator of sanitary quality of foods and water. They are defined as rod-shaped Gram-negative non-spore forming bacteria which can ferment lactose with the production of acid and gas when incubated at 35–37°C.

Coliform can be found in the aquatic environment, in soil and on vegetation; they are universally present in large numbers in the feces of warm-blooded animals. While coliforms themselves are not normally causes of serious illness, they are easy to culture and their presence is used to indicate that other pathogenic organisms of fecal origin may be present. Such pathogens include bacteria, viruses, or protozoa and many multi-cellular parasites. Coliform procedures are performed in aerobic or reduced oxygen conditions. The fluoride, nitrate, residual chlorine, iron and ammonia were found satisfactory. But the concentration of DO, phosphorus chloride and hardness were found on higher side. Chloride details has already studied in introduction chapter, let’s take the details of effects of phosphorus and Hardness as below.

Phosphorus: Phosphorus is a common constituent of agricultural fertilizers, manure, and organic wastes in sewage and industrial effluent. It is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of rivers and lakes. Soil erosion is a major contributor of phosphorus to streams. Bank erosion occurring during floods can transport a lot of phosphorous from the river banks and adjacent land into a stream. Phosphorus gets into water in both urban and agricultural settings. Phosphorus tends to attach to soil particles and, thus, moves into surface-water bodies from runoff. A USGS study on Cape Cod, Massachusetts showed that phosphorus can also migrate with ground-water flows. Since groundwater often discharges into surface water, such as through stream banks into rivers, there is a concern about phosphorus concentrations in groundwater affecting the water quality of surface water. Phosphorus is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of rivers and lakes.

Hardness: Hard water is water that has high mineral content (in contrast with "soft water"). Hard water is formed when water percolates through deposits of calcium and magnesium-containing minerals such as limestone, chalk and dolomite. Hard drinking water is generally not harmful to one's health, but can pose serious problems in industrial settings, where water hardness is monitored to avoid costly breakdowns in boilers, cooling towers, and other equipment that handles water. In domestic settings, hard water is often indicated by a lack of suds formation when soap is agitated in water, and by the formation of lime scale in kettles and water heaters. Wherever water hardness is a concern, water softening is commonly used to reduce hard water's adverse effects.

There is no known health risks associated with the consumption of hard water. In fact, studies have shown that people who regularly consume hard water throughout their lifetime have a lower rate of cardiovascular disease.

There are some problems associated with hard water. These include:

- gray staining of washed clothes
- scum on wash and bath water following use of soap or detergent
- reduced lathering of soaps
- buildup of scale on electric heating elements and boilers
- reduced water flow in hot water distribution pipes due to scale buildup
- accumulation of whitish-gray scale in tea kettles and other containers used to boil water

Water's hardness is determined by the concentration of multivalent cations in the water. Multivalent cations are cations (positively charged metal complexes) with a charge greater than 1+. Usually, the cations have the charge of 2+. Common cations found in hard water include Ca^{2+} and Mg^{2+}. These ions enter a water supply by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium). Rainwater and distilled water are soft, because they contain few ions.

The following equilibrium reaction describes the dissolving and formation of calcium carbonate:

$$CaCO_3 (s) + CO_2 (aq) + H_2O (l) \leftrightharpoons Ca^{2+} (aq) + 2HCO_3^{-} (aq)$$

The reaction can go in either direction. Rain containing dissolved carbon dioxide can react with calcium carbonate and carry calcium ions away with it. The calcium carbonate may be re-deposited as calcite as the carbon dioxide is lost to atmosphere, sometimes forming stalactites and stalagmites. Calcium and magnesium ions can sometimes be removed by water softeners.

Dissolve Oxygen: The dissolved oxygen (DO) is oxygen that is dissolved in water. The oxygen dissolves by diffusion from the surrounding air; aeration of water that has tumbled over falls and rapids; and as a waste product of photosynthesis. A simplified formula is given below: Photosynthesis (in the presence of light and chlorophyll):

Carbon dioxide +	Water	-------------->	Oxygen +	Carbon-rich foods
CO_2	H_2O		O_2	$C_6H_{12}O_6$

Fish and aquatic animals cannot split oxygen from water (H_2O) or other oxygen-containing compounds. Only green plants and some bacteria can do that through photosynthesis and similar processes. Virtually all the oxygen we breathe is manufactured by green plants. A total of three-fourths of the earth's oxygen supply is produced by phytoplankton in the oceans.

4.2 Variation of Water Quality:

If water is too warm, there may not be enough oxygen in it. When there are too many bacteria or aquatic animal in the area, they may overpopulate, using DO in great amounts.

Oxygen levels also can be reduced through over fertilization of water plants by run-off from farm fields containing phosphates and nitrates (the ingredients in fertilizers). Under these conditions, the numbers and size of water plants increase. Then, if the weather becomes cloudy for several days, respiring plants will use much of the available DO. When these plants die, they become food for bacteria, which in turn multiply and use large amounts of oxygen. and this depleting all the oxygen.

How much DO an aquatic organism needs depends upon its species, its physical state, water temperature, pollutants present, and more. Consequently, it's impossible to accurately predict minimum DO levels for specific fish and aquatic animals. For example, at 5 oC (41 oF), trout use about 50-60 milligrams (mg) of oxygen per hour; at 25 oC (77 oF), they may need five or six times that amount. Fish are cold-blooded animals. They use more oxygen at higher temperatures because their metabolic rates increase. Numerous scientific studies suggest that 4-5 parts per million (ppm) of DO is the minimum amount that will support a large, diverse fish population. The DO level in good fishing waters generally averages about 9.0 parts per million (ppm).

Figure 1. CHLORIDE CONCENTRATION VARIATION

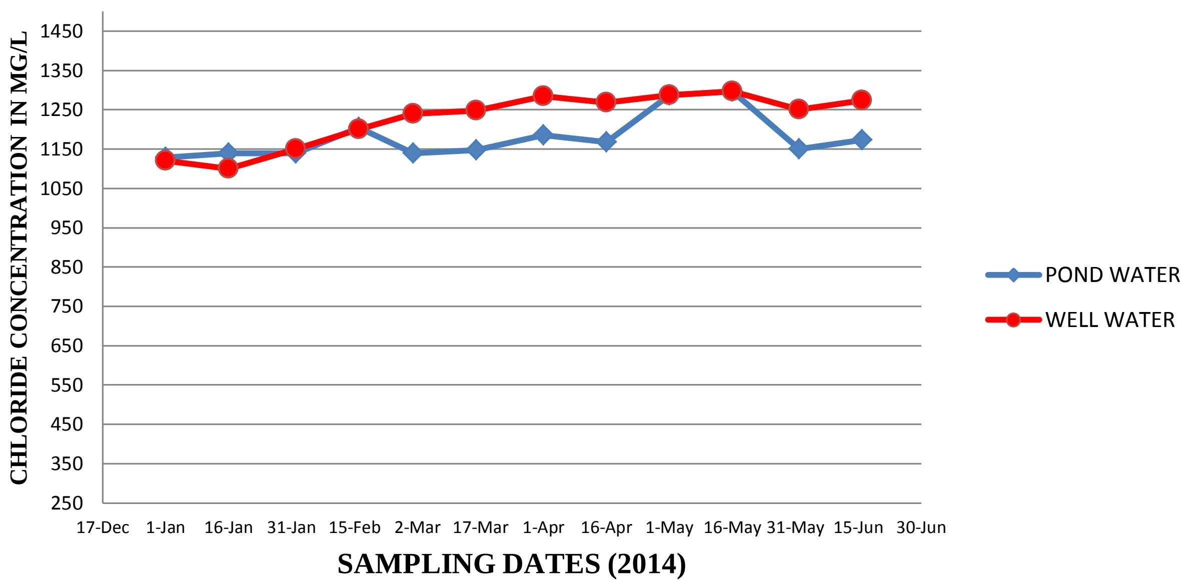

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Figure 2. VARIATION OF TDS CONCENTRATION IN WELL AND POND WATER

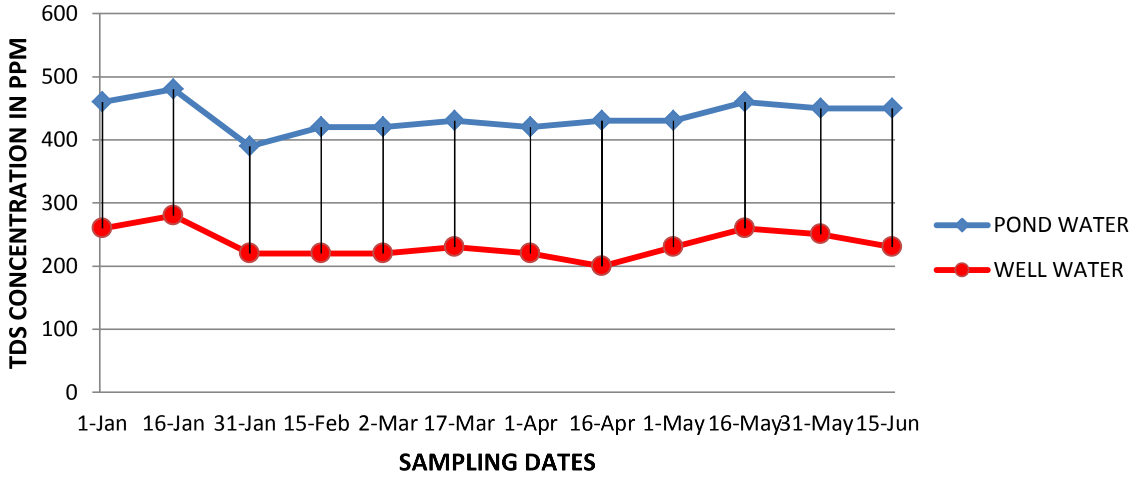


Figure 3. Concentration of phosphate

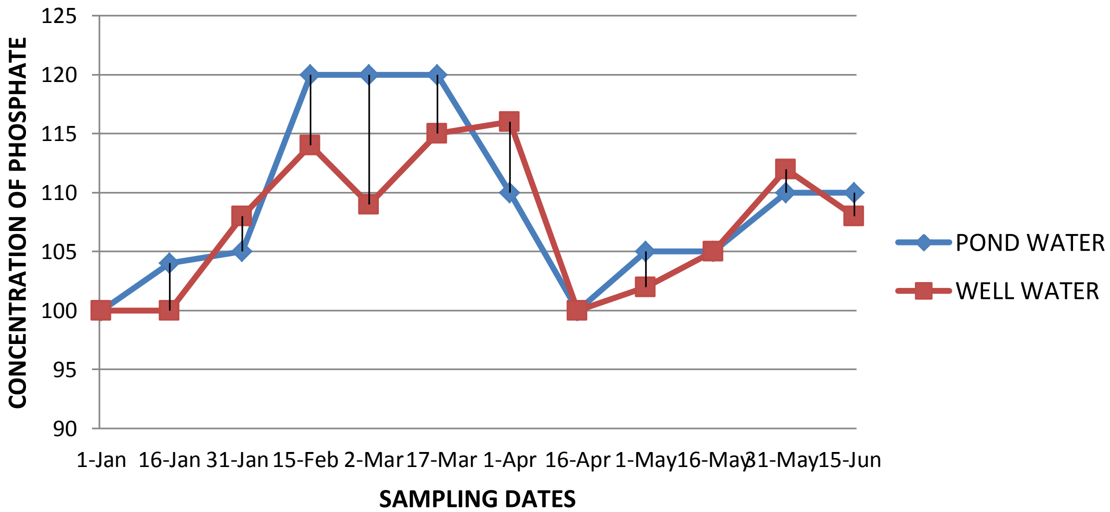
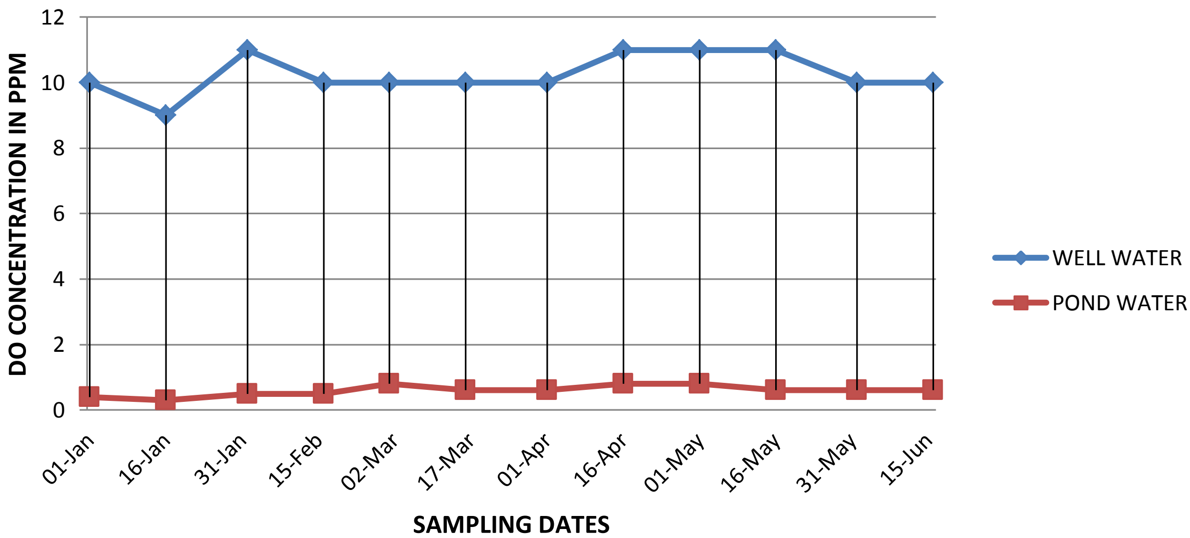


Figure 4 DISSOLVE OXYGEN CONCENTRATION



V. CONCLUSIONS

From the present study, major conclusions were drawn and are listed below.

1. The DO level in the pond water is found very low comparing to well water. This may be due to the presence of green algae in the water. The DO concentration also varies with Temperature. Low temperature shows high DO level in water.
2. Due to very low DO level, there is no aquatic life surviving in the pond of this village.
3. Phosphate level is fluctuating up and down with time. There is no major change. High phosphate level is creating eutrophication problem in some area.
4. TDS concentration is also fluctuating up and down with time and has no major change with time as the outflow and in flow of water is maintaining the concentration of TDS.
5. One of the solutions is maintaining continuous artificial aerations in the pond to increase the current DO level. This can be achieved by providing electrical pump and fountain system.
6. The rain water can also diverted by constructing little drains from catchment areas and other nearby sources and by means of small tributaries. Another best way of receiving water is by means of ground water discharge. Special attention should be given for replenishment through ground water recharge. Programs should be needed to collect flood water for recharging ground water and filling water bodies.
7. There should be control on the discharge of untreated waste of high organic content from the village streets and residences. Treated water must not be mixed with untreated water. Additional low cost ETP's should be constructed nearby and obstruct to contribute pollutant load.
8. Provision of conveying storm water to the pond also helps in recharging of pond. Storm Water can be collected or directly allowing it to enter drains can be a feasible option.
9. Encroachment on pond bank need to be removed so that recharging of pond can takePlace. A slow sand filter can also be installed for the periodic purification of pond water.
10. Artificial aeration is also an excellent option for maintaining the healthy quality of pond water by regaining purification and by supporting aquatic life.

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