International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 10, October 2018, pp. 659–667, Article ID: IJCIET_09_10_069
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=10
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

ANALYSIS OF GROUNDWATER QUALITY AFTER RAINWATER HARVESTING IN COASTAL AREAS: A CASE STUDY OF HPCL, MAHUL REFINERY

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ABSTRACT

Water resources are essential for existence and development of global community. Ground water is considered as one of the primary resources for developmental activities. Ground water quality can be adversely affected or degraded as a result of human activities that introduce contamination into the environment. In industrial and coastal location, the saline water intrusion resulted in contamination of the potable ground water aquifers. This study leads to crucial issues such as water availability and its quality in coastal areas. Twelve parameters were selected as indicators of the groundwater quality which include pH, Hardness, Chlorides, Sulphate Dissolved Solids, Calcium, Alkalinity, Magnesium and metals etc. The analysis is carried out on the basis of experimentation by standard sampling methods, for three different locations for pre -monsoon and post monsoon from 2016 to 2018.The analysis and comparison of the previous data shows that hardness, chlorides, TDS were not in permissible limit and too high before installation of Rain water harvesting system. After the installation of Rain Water Harvesting system, the values reduced as per ISO standards. The rainwater recharged and dilutes the salt concentration in ground water and improves the quality of groundwater in the coastal areas.

Key words: Rainwater Harvesting, Ground water, Coastal Area, Aquifers, Parameters.

Cite this Article: Jyoti J. Nimje and Dr A.S. Wayal, Analysis of Groundwater Quality after Rainwater Harvesting in Coastal Areas: A Case Study of HPCL, Mahul Refinery, *International Journal of Civil Engineering and Technology (IJCIET)* 9(10), 2018, pp. 659–667.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=10

1. INTRODUCTION

Water is a necessary and important component for our life support system. With fluctuating and increasing contamination of surface water, ground water has an important and increasing role to play. It has an excellent natural quality, usually free from pathogens, color and turbidity and can be consumed directly without treatment. However, the availability of ground water is getting limited, and not protected from deterioration. The extraction of excessive quantities of ground water has resulted in drying up of wells, damaged ecosystems, land subsidence, salt water intrusion and depletion of the resources. Ground water quality is increasingly getting affected by industrial, agriculture and urban wastes, which leach or are injected into underlying aquifers. It has been proved that once pollution has entered the subsurface environment, it may remain dissembled for many years, becoming spread over wide areas of ground water aquifer and make ground water supplies unsuitable for consumption and other uses. The rate of depletion of ground water levels and deterioration of ground water quality is of concern in major cities and towns of the country. The prevailing climatic conditions, topography, geological formations and use and abuse of this vital resource have significant effect on the characteristic of the water, because of which its quality varies with locations.

The rain water harvesting is the best available option which plays an important role in the local and regional hydrological cycle. Direct infiltration, collecting rainwater in ponds /reservoir or recharging groundwater aquifers through bore hole are general methods used for harvesting rain water in heavily populated cities and coastal regions. Apart from the quantitative improvement, the quality of groundwater also gets improved as a result of dilution of certain chemical constituents and dissolved solids. In salinity ingress areas where there is saline groundwater, or the chemical constituents are more than the desirable or maximum permissible limits, the rainwater recharging the aquifers dilutes and make it usable. The authors carried out various studies on ground water quality improvement. Alawneh A[1] explained the modelling of ground water recharge by rain water harvesting with case study of Wadi Bayer.Jebamalar[5] have studied a comparative analysis of hydrologic responses to rainwater harvesting. Gurdeep Singh[4] have done assessment of ground water quality in mining areas of Goa. In 2012 Mohd Saleem[8] and Sarala C[10] carried out analysis assessment of ground water quality parameter improvement using rain water harvesting system in Jamia Millia South Delhi and Jawaharnagar Hydrabad. Saumya Singha[11] have studied ground water recharge in urban areas by rain water harvesting also T.P Abegunlin studied roof age effect on the quality of harvested rainwater and its health implication in a selected location Southwest Nigeria. Khwajam Anwar[6] and Vanita Aggarwal in 2014 also did analysis of ground water quality of Aligarh city using water quality index.

2. LOCATION AND EXTENT

Chembur is a suburb in Eastern Mumbai, Maharashtra, India, having many major petrochemical industry, Oil refineries, Fertilizer plants and Power industry situated in the region. The Latitude is 19.01794 and longitude is 72. 90321.The average rainfall of this area is 2800 mm. Chembur was ranked 46th in a list of the most polluted industrial clusters in India. The CEPI score of 63.2 comes under the criteria of severely polluted areas which shall be kept under surveillance and pollution control measures are to be efficiently implemented. Being industrial and coastal location, the saline water intrusion resulted in contamination of the potable ground water aquifers. The Refinery is spread over vast area of 321 acres of land at Mahul road Chembur Mumbai which is situated in coastal area. This Refinery is facing acute scarcity of fresh water since last few years due to addition of new processing units. The deficit in daily fresh water supply is being mitigated by outsourcing of water. The uninterrupted supply of this outsourced water is also not guaranteed, and many a times leads to emergency situations resulting in shutdowns and slowdowns. Refining process of plants also depleting the quality of ground water. The study attempts to made for improving the situation of ground water quality in this coastal region.

For this, the impact of rain water harvesting on groundwater quality has been studied in the HPCL Refinery located in the area. The location map of the study area is shown in figure 1

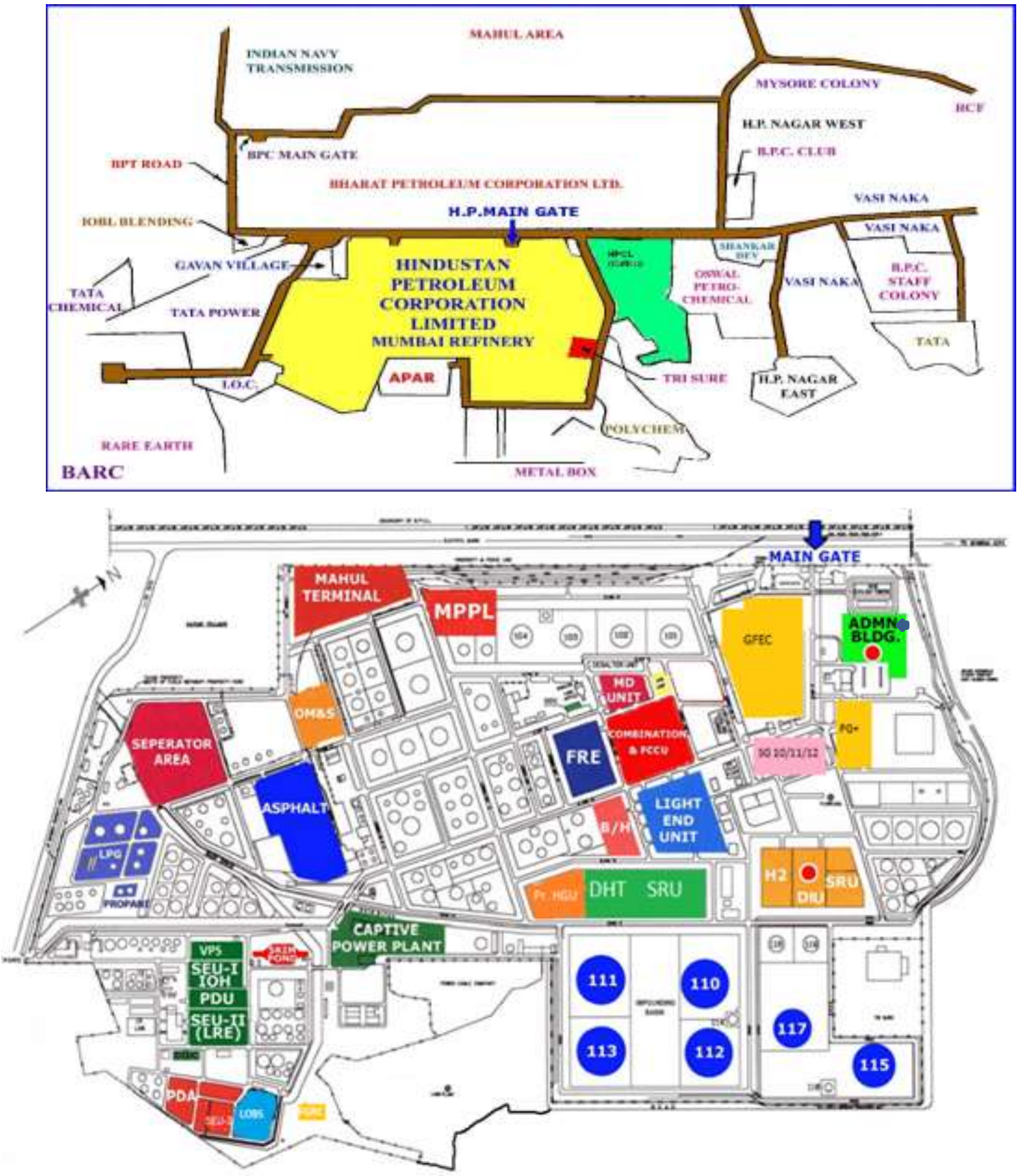


Figure 1 Location map of the study area

3. OBJECTIVE OF THE STUDY

The objective of the study is to analys the groundwater quality of the coastal areas after installation of rain water harvesting system. The analysis is being carried out at different locations for Pre-Monsoon period and Post-Monsoon period. Comparative Study is done for quality of the groundwater test results in order to ascertain the overall impact of Rainwater Harvesting on groundwater quality of the coastal area.

4. METHODOLOGY

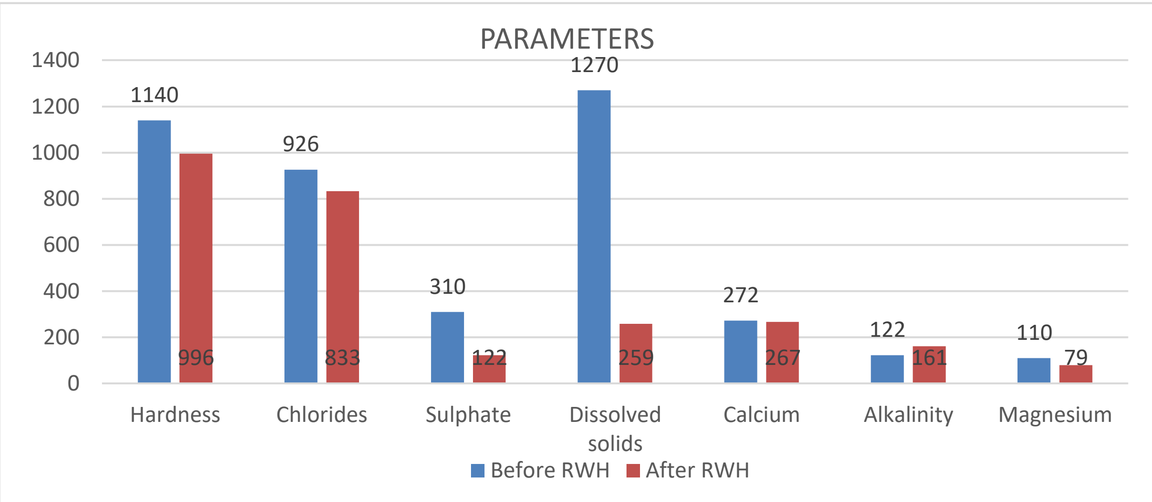
In order to ascertain the degree of contamination in the groundwater due to industrial activity, pollution and other activities in coastal area, the study conducted to cover both the pre-monsoon and post-monsoon periods. The three years data of three different locations where rain water harvesting system is installed were collected to know the analytical status of the groundwater quality in the area. The Samples were collected in the month of February to June for the year 2016 to 2018 and analysed. The twelve parameters were selected and quality analysis has been carried out by standard method prescribed as per IS 10500-1994 codes. All the groundwater quality test results of the location are compiled and comparative study is being done to reveal the overall impact of rainwater harvesting on groundwater quality.

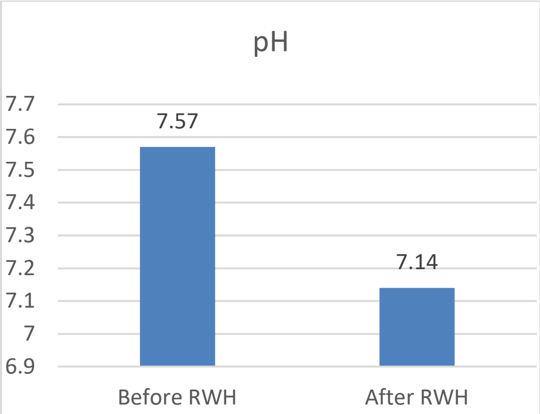
4.1. Analysis and Comparison of Groundwater

The ground water quality monitoring studies were undertaken during the months of February 2016, February 2017 and Feb 2018. The water samples were collected from Borewells located in HPCL Refinery where, the Rain Water Harvesting system is installed. The samples collected from three different borewells. All the ground water samples were tested in standard sampling procedures. Table -1 to 3 shows the water analysis results of all three locations .and Figure 1 to 3 shows the comparative study before and after rainwater harvesting

Table 1 Analysis of Ground water quality at Location :1

S.No	Parameters	Before RWH	After RWH			Average RWH
			Feb 2016	Feb 2017	Feb 2018	
1	pH	7.57	7.19	7.08	7.16	7.14
2	Total Hardness	1140	1345.2	608	1034	996
3	Chloride	926	1079.7	498.99	919.7	833
4	Sulphate	310	140.2	79.42	147	122
5	Dissolved Solids	1270	334.7	135.1	306.5	259
6	Calcium	272	325.7	190	286	267
7	Alkalinity	122	150	176	156.8	161
8	Magnesium	110	127.4	31.92	76.7	79
9	Iron	ND	0.2	0.084	0.07	0.12
10	Manganese	ND	0.23	ND	0.14	0.12
11	Zinc	0.08	<0.05	ND	ND	<0.05
12	Lead	ND	<0.01	ND	ND	<0.01





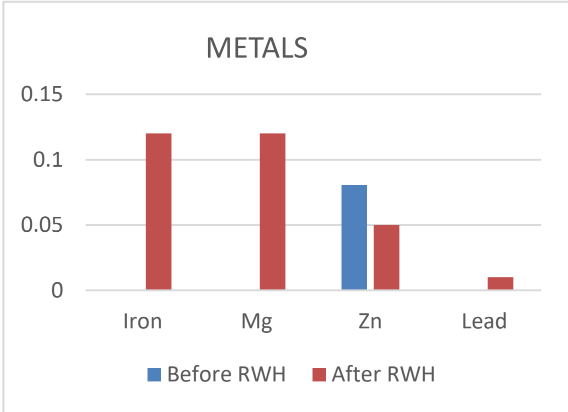
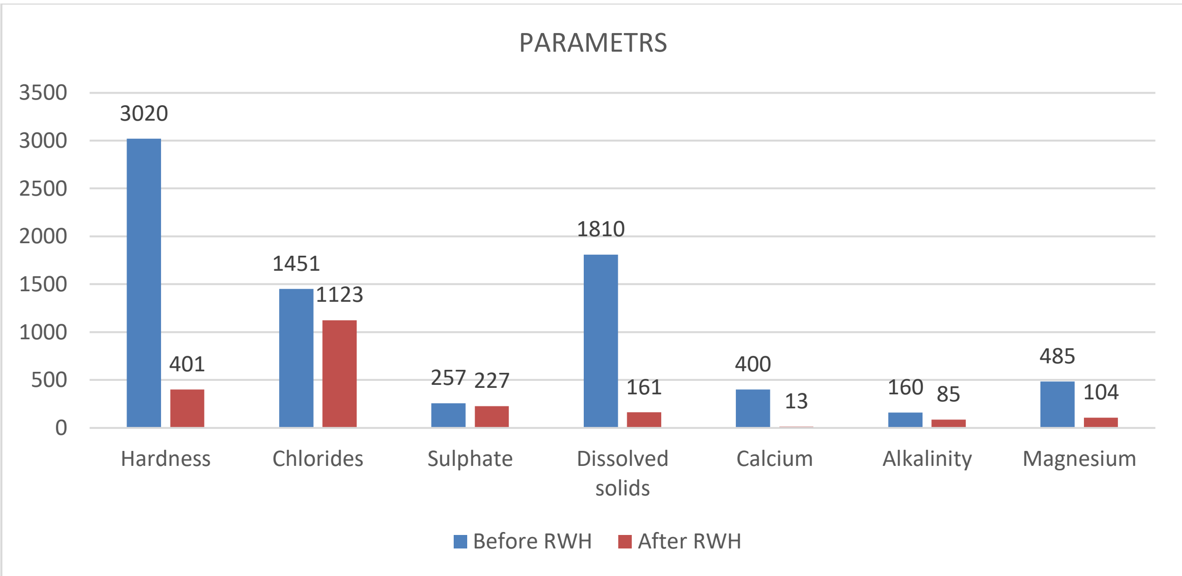
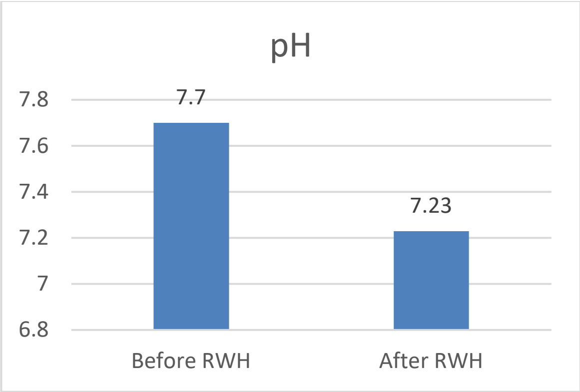


Figure 2 Comparison Before and After Rain Water Harvesting

Table 2 Analysis of Ground water quality at Location :2

S.No	Parameters	Before RWH	After RWH			Average RWH
			March 2016	June 2017	Feb 2018	
1	pH	7.70	7.14	7.66	6.89	7.23
2	Total Hardness	3020	433	405.6	364.7	401
3	Chloride	1451	1402.89	1800.2	166.82	1123
4	Sulphate	257	406.17	230.33	43.59	227
5	Dissolved Solids	1810	100.58	83	300	161
6	Calcium	400	15.12	12.48	11.58	13
7	Alkalinity	160	53.2	30	171.6	85
8	Magnesium	485	132	ND	75.2	104
9	Iron	ND	4.2	0.2	1.7	2.0
10	Manganese	0.51	0.46	0.35	0.41	0.41
11	Zinc	0.11	ND	ND	0.08	0.08
12	Lead	0.01	ND	ND	0.13	





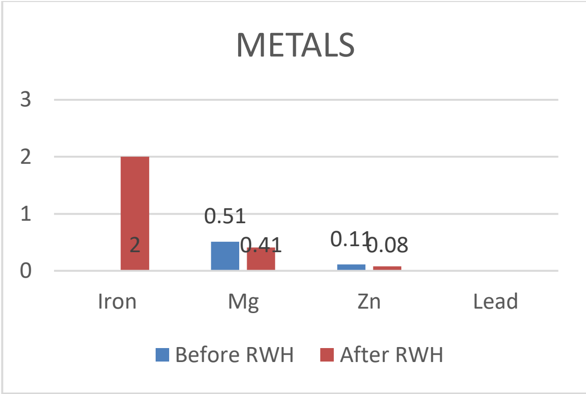
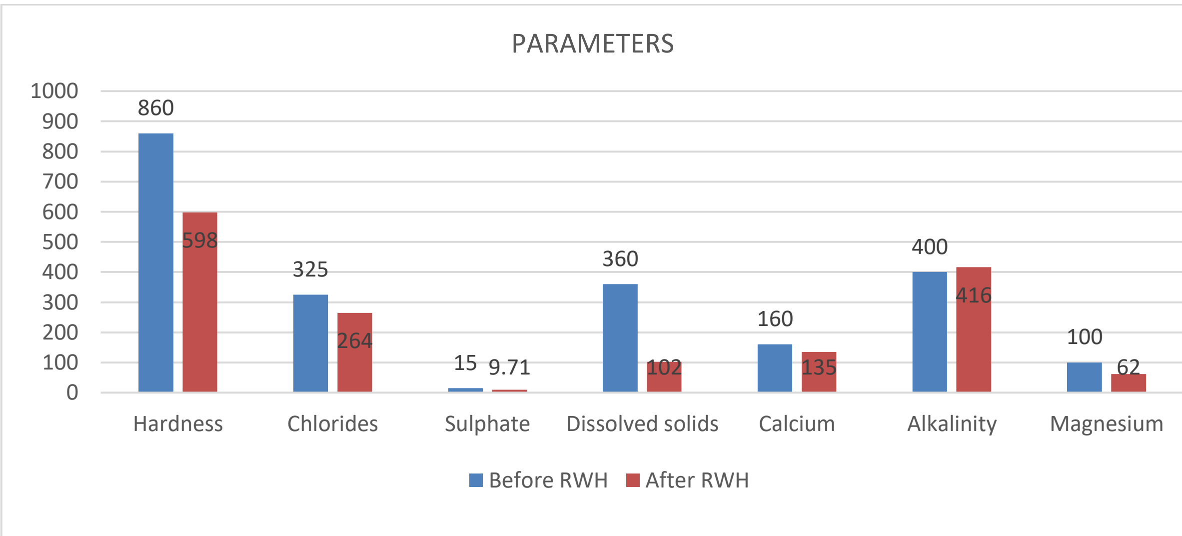
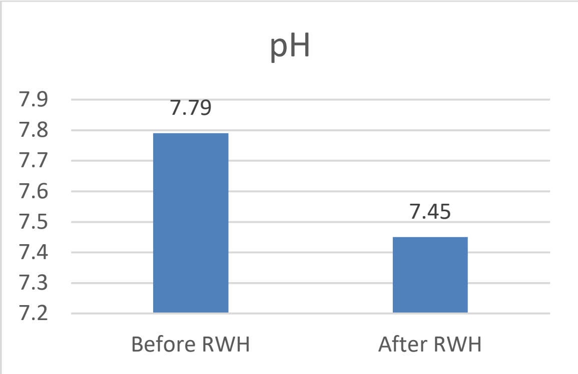


Figure 3 Comparison Before and After Rain Water Harvesting

Table 3 Analysis of Ground water quality at Location :3

S.No	**Parameters**	**Before RWH**	**After RWH**			**Average RWH**
			March 2016	June 2017	March 2018	
1	pH	7.79	7.94	7.47	6.96	7.45
2	Total Hardness	860	912	446	436.16	598
3	Chloride	325	339.97	273.96	178.07	264
4	Sulphate	15	6.5	11.91	10.72	9.71
5	Dissolved Solids	360	121.3	97.2	86.9	102
6	Calcium	160	259.2	90.4	56.4	135
7	Alkalinity	400	392.5	353.4	502.9	416
8	Magnesium	100	63.36	52.8	70.84	62
9	Iron	ND	0.37	0.234	0.2	0.27
10	Manganese	2.15	1.49	0.88	0.8	1.05
11	Zinc	0.10	ND	ND	ND	
12	Lead	ND	ND	ND	ND	





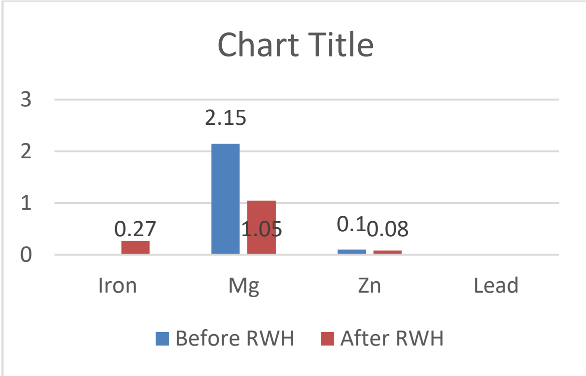


Figure 4 Comparison Before and After Rain Water Harvesting

5. RESULT AND DISCUSSION

S.No	Parameter	Comments
1	pH	The pH is the negative logarithm of Hydrogen ion concentration in moles per litre. pH values ranged from 7.57 to 7.79 before rain water harvesting and 7.14 to 7.45 after rain water harvesting. The pH is within permissible limit in all the locations i.e. 6.5 to 8.5.
2	Total hardness	Total hardness is a measure of the capacity of water to the concentration of calcium and magnesium in water and is usually expressed as the equivalent of CaCo3 concentration. The hard water is unsuitable for domestic use. The hardness of the water samples ranges between 860 to 3020 before rain water harvesting and 401 to 996 after rain water harvesting. The total hardness is relatively high above the standard limit prescribed by BIS standards. 300 to 600 mg/l in all the samples due to presence of calcium, magnesium, chloride and sulphate ions. The values are higher before harvesting.
3	Chlorides	The chlorides content of underground water varied from 325 to 1451 mg/l before rain water harvesting and 264 to 1123 mg/l after rainwater harvesting. In study area chloride concentration increase the maximum permissible limit i.e.250-1000mg/l prescribed by BIS.The concentrations of chloride vary widely in natural water and it directly related to mineral content of the water.
4	Sulphate	Sulphate ion is one of the important anion present in natural water which produce catharsis, dehydration and gastrointestinal irritation effect. In present investigation Sulphate concentration was ranged from 15.0 to 310 mg/l before rain water harvesting and 9.71 to 227 mg/l after rain water harvesting. samples levels are within the permissible limit i.e.200 -400 mg/l.
5	Total dissolved solid	Total dissolved solid is used as an indication of aesthetic characteristics of drinking water. The TDS values in the present study vary from 360 to 1810 mg/l before rain water harvesting and 102 to 259 mg/l after rain water harvesting. Samples were found within the standard limit i.e.500 – 2000 mg/l prescribed by BIS. Water with high Total dissolved solids are of inferior palatability and may induce an unfavourable physiological reaction in the transient consumers and gastrointestinal irritation. Total dissolved solids arise naturally from the weathering and dissolution of rocks and soils.
6	Calcium	The presence of Calcium in the ground water is from silicate mineral group such as pyroxene and amphibole in the igneous rocks. Calcium contents are available in most of the rocks abundantly and also due to its higher solubility. The permissible limit of calcium is 75 – 200 mg/l prescribed by BIS. in study area concentrations are varied from 160 to 400 mg/l before rain water harvesting and it ranges between 13 to 267 mg/l after rain water harvesting.
7	Alkalinity	The alkalinity varies from 122 to 400 mg/l before rain water harvesting and 85 to 416 mg/l after rain water harvesting. The samples were found within the standard limit i.e 200 -400 mg/l prescribed by BIS. Water with high alkalinity is called hard water The most common mineral compound causing alkalinity is calcium carbonate, which can come from rocks such as limestone or can be leached from dolomite and calcite in

		the soil. If alkalinity is high it imparts a bitter taste to water.
8	Magnesium	Magnesium derived from dissolution of magnesium calcite, gypsum and dolomite from source rocks. Magnesium is an essential ion for functioning of cell in enzyme activation but at higher concentration it is consider as laxative agent. Concentrations varied from 100 to 485 mg/l before rain water harvesting where as it ranges between 62 to 104 mg/l after rain water harvesting. Results were high as per the standard limit i.e.30-100 mg/l prescribed by BIS.
9	Iron	Iron concentrations in this study not detected before rain water harvesting and varies from 0.12 to 0.27 after rain water harvesting samples were found within the standard limit i.e.0.30-1.0 mg/l prescribed by BIS. Iron is a common metallic element found in the earth's crust Iron can affect the flavour and color of food and water. Iron is biologically an important element which is essential to all organisms and present in haemoglobin system.
10	Manganese	Manganese 0.51 to 2.15 before Rain water harvesting and reduced 0.12 to 0.41 after rain water harvesting. samples were not found in the standard limit i.e.0.1 – 0.3mg/l as prescribed by BIS.
11	Zinc	The concentration of zinc varies from 0.08 to 0.11 before rain water harvesting and 0.05 to 0.08 after rain water harvesting which found within permissible limit i.e. 5 - 15 mg/l prescribed by BIS
12	Lead	Lead varies is 0.01 in one location, it is less than 0.01 which is within permissible limit

6. CONCLUSIONS

In the present study ground water quality has been analysed to assess the impact of rain water harvesting on ground water quality in coastal region. The analysis and comparison of three years data shows that out of twelve parameters values of most of the parameters were too high and not within permissible limit before the installation of rain water harvesting system. After installation of harvesting structure, the values reduced as per standard limit prescribed by Bureau of Indian standards. Total dissolved solids showed higher values of salinity in the region. The values of Hardness, chlorides Magnesium are also high. Metals are not detected in some locations but there is improvement in levels of metals after installation of rain water harvesting. The study portrays the urgent need of effective management of water resources by installing rain water harvesting system in the coastal region which improves the quality of water.

ACKNOWLEDGEMENT

Authors are thankful to Hindustan Petroleum to give opportunity to collect information of the study area and also thankful to Mr Harsh Khujur, Chief Manager Technical for his guidance to accomplish the works.

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