Journal of Critical Reviews

ISSN- 2394-5125 Vol 6, Issue 6, 2019

# IMPROVEMENT IN GROUND WATER QUANTITY USING RAIN WATER HARVESTING SYSTEM IN COASTAL AREA

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*Received: 25.11.2019* *Revised: 24.12.2019* *Accepted: 27.12.2019*

**Abstract**

The increasing pressure from economic activities and over extraction of groundwater has caused sea water intrusion into the water table in coastal areas. This increase in salinity has brought in issues like paucity of drinking water, reduction in areas under cultivation, reduced yield per hectare, and health hazards for people and cattle. Petroleum refineries often cause soil and groundwater pollution, due to potential leakages of petroleum products from underground or surface tanks and pipes at several stages of the petroleum elaboration. The environmental impact resulting from such activities may be extremely negative, pointing out the need for immediate remediation actions, as well as uptake of adequate prevention measures. The study is an attempt to focus on the methodology of ground water recharge by the rainwater harvesting at HPCL, Mumbai Refinery situated in coastal area. Quantity analysis conducted on the groundwater samples collected during the month of April 2016 in pre monsoon period and in the month of November 2016, in the post-monsoon period reveals this truth of qualitative improvement of groundwater through rainwater recharge to the aquifers, Initially the water table at Mumbai Refinery was in the range of 6.5 m – 8.0 m before rainwater harvesting and 2.5 m–7.0 m after rainwater harvesting .The rainwater recharge improves the quantity of groundwater by improving water table depth. The annual aggregate rupee savings by way of total rain water harvesting potential at Mumbai Refinery comes to Rs.78 lacs. The available soil at Mumbai refinery at shallow depth is Yellowish brown medium to dense silty sand which is having good characteristics to recharge groundwater. The study portrays the urgent need of Effective management of water resources by installing rain water harvesting system at other location of study area and in the coastal region.

**Key words:** Rain water harvesting, artificial recharge, Rainfall Intensity, coastal Area, Refineries, water Table Fluctuation.

 DOI: http://dx.doi.org/10.22159/jcr.06.06.32

## Introduction

The water demand is increasing in the country has brought forward the realisation that the planned augmentation of water storage in the ground water reservoirs by suitable recharge techniques will incease the available ground water supplies as well as natural water storage facilities. Rain water harvesting aims at increasing the recharge artificially through a suitably designed and implemented structure which will transfer the runoff water available over the surface of the earth to a water bearing formation (aquifer) available at any depth **.**The coastal of India are among the most densely populated areas of India. Ground water is an important source of water supply for various uses coastal areas of most of the cities. Over exploitation of ground water from coastal fresh water aquifer system, existing in delicate hydrodynamic equilibrium with sea water increases the risk of sea water ingress into these aquifers. India has a dynamic coast line of about 7500 km length, including the main land coast line of about 5400 km. Out of total population of India about 25 percent of population of India resides in the coastal tracts of the country .The Central Ground Water Board in collaboration with UNDP and State Ground Water Agencies has conducted project on evaluating the technical feasibility of artificial recharge in augmenting the depleted aquifers in the Mehsana area and also the study of controlling the saline ingression in coastal belt of Gujarat . Vijay kumar (2005) has evaluated the ground water potential by ground water estimation committee (GEC 1997) norms. Sharma and Jain (1997) conducted an experiment in Nagpur city where 80,000 litres of water , collected from the roof top 100 m2 area ,was recharged. Jebamalar (2011) investigate the implementation of rainwater harvesting structures and its hydrologic responses ( in terms of quantity and quality of water) in two hydrocoastal belt of Gujarat-geologically different localities of Chennai city in Tamilnadu state, India

The annual fresh water consumption at Mumbai Refinery for various process and non-process requirements is approx. 35lakh KL (Kilo Liters). Out of this total requirement, on an average 34.58 lac KL is supplied by BMC. To meet the operating requirement of fresh water the deficit of 0.42lakh KL is outsourced and carted to refinery through water tanker. The purchase cost of this outsourced water is Rs.150 per KL. The un-interrupted supply of this outsourced water is also not guaranteed and many a times leads to emergency situations resulting in shutdowns and slowdowns. A survey of rain water harvesting potential at major locations has indicated an aggregate quantity of 1.028 lac KL.The beneficial harvesting of this quantity of rain water and recharging it to the water table can help mitigate problem of fresh water shortage to a small extent.

## Study Area

Mumbai is coastal city and business capital on west coast of India, shows shoreline of 167 KM. It has 15% covered area and the remaining area is open space. Being a Metropolitan city Mumbai is facing multifaceted problems regarding water availability, quantity and quality. The area of study is the Mumbai Refinery where the rainwater harvesting structures were installed. The area is spread over vast area of 321 acres of land at Mahul road Chembur, Depending upon the area of refinery it is divided into different Zones for the installation of rainwater harvesting structures. The layout map of this location is shown in figure 1.This work is an attempt to analysing the impact of rainwater harvesting on ground water quantity in coastal area..

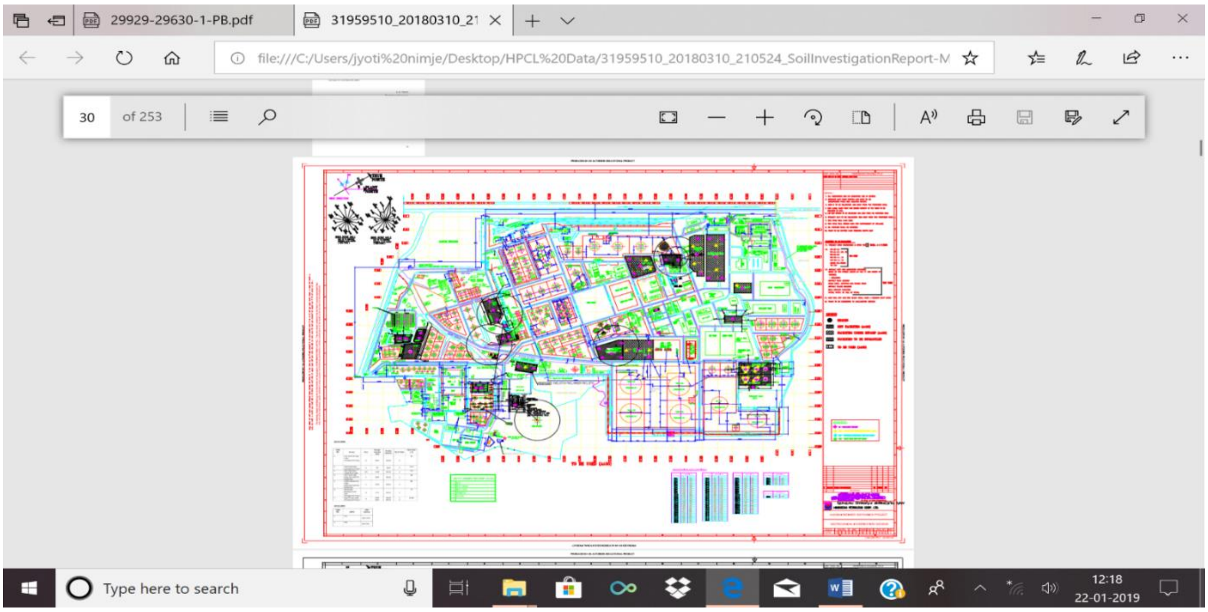


**Fig.1**

**Meteorology of the Study Area**

The climate of the district is characterized by an oppressive summer, dampness in the atmosphere nearly throughout the year and heavy south – west monsoon rainfall from June to September. The mean minimum temperature is 16.3°C and the mean maximum temperature is 32.2°C. The normal annual rainfall over the district varies from about 1800 to about 2400 mm. Chembur is 14 m above sea level and located at 19.04° N 72.89° E. The rainfall in chembur area is confined to the month June, July, August and September (i.e. 90%) and rest of the 10% in the other nine months namely- February, March, April, May. October and November goes dry. According to Meteorological Department the average rainfall is about 611.0 mm per year with the humidity varying from 36% - 96% and temperature variation from 17º C to 37º C. The evaporation recorded as 1.7 m. The Specific Yield varies in the study area from 16% to 20%. In order to evaluate the rain water harvesting potential, a detail survey was carried out and the average rain fall considered is 28 mm and Surface Rain Water Harvesting Coefficient considered is 85% which is a standardized number. Peak Intensity of rainfall is the quantum of rainfall expected at peak intensity in 15 mins, since the trend of rain is to fall in heavy bursts followed by mild rains. The peak intensity of Mumbai is taken at 25 mm of rainfall.

**Objective of the Study**

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

**Methodology**

The ground water quantity monitoring studies were undertaken during the months of April 2016, and Nov 2016. from Borewells located in the area where the Rain Water Harvesting is installed. The borewells holes drilled in the geotechnical investigation are analyses carefully water samples were collected Initially a survey was conducted to collect the details of implemented rain water harvesting structure and analysed. The annual water table fluctuations were measured at different locations of the study area for pre- monsoon and post monsoon water level . There after the impact of rainwater harvesting on the ground water quantitative potential was established based on the mathematical calculations. The impact of possible recharge for rain water harvesting system was assessed using GEC norms 1997 by water table fluctuation method

**Geological/Lithological Interpretations**

The data of fifty-two borewells holes drilled in the geotechnical investigation are reviewed carefully along with another field test carried out. The results of laboratory tests on soil and rock samples are also studied. In majority of borehole locations i.e yellowish brown highly weathered basalt rock layers is available at shallow depth i.e. between 1.5 - 4.5 m depth below existing ground levels and in some location soil layer are between 5.0m to 12m. The Top Soil layer i.e. layer 1 is from 1.0m to 1.5m, second layer is yellowish brown very stiff to hard sandy silty clay is from 1.5m to 3.0 m ,third layer is yellowish brown medium to dense silty sand (murum), is from 3.0 m to 4.0 m fourth layer is yellowish brown highly weathered basalt is from 1.5 to 4.5m and fifth layer is grey/black basalt **.**Ground water table is available at 2.5 m to 7.0 m depth below existing ground level

**Principles of Artificial Recharge of Groundwater**

Artificial recharge is the process by which the ground water reservoir is augmented at a rate exceeding that under natural conditions of replenishment. The basic purpose of artificial recharge of ground water is to restore supplies from aquifers depleted due to excessive ground water development. Any man-made scheme or facility that adds water to an aquifer may be considered to be an artificial recharge system. The most artificial recharge projects for specific purpose of saving or storing fresh water for subsequent use. Among these projects some may serve the dual purpose of eliminating objectionable amounts of water at the land surfaces and, at the same time putting this water into reserve for eventual extraction.

The various hydraulic effects are generated by artificial recharge as a result of the head, which is applied in the recharge area and the mass of the water, which is introduced into the aquifer through the recharge area, the piezometric effect and the volumetric effect results in a rise in the piezometric surface in the unconfined aquifers and a rise of the artesian pressure in the confined aquifers. It is to factors which create a damping effect related to shape of the piezometric surface to the geological and hydraulic boundaries of the aquifer and to the type of location of the recharging device secondly, it is related to quotient T/C (T=transmissivity coefficient; C=replenishment coefficient which is equivalent of storage coefficient). Finally, it is related to the artificial recharge yield and the duration of operation. Other factors such as capillary forces water temperature and presence of air bubbles in the aquifers also have in impact on the piezomtric effect. The volumetric effect is related to specific yield, replenishment coefficient, the transmissivity coefficient and the boundary coefficient model studies that were checked through filled experiments have demonstrated that the bulk of the recharge water move according to the spreading out effect, with a speed related to the recharge flow, the other sliding effect, with a speed related to ground water flow.The detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the sites and the type of recharge. In particular, hydraulic boundaries inflow and outflow of waters; storage capacity; porosity; hydraulic conductivity; transmissivity; natural discharge of springs; water resources available for recharge natural recharge; water balance; lithology; depth of aquifer; and tectonic boundaries.

**Rain Water Harvesting at Study Area**

In order to study rooftop harvesting potential the total roof-top areas of the buildings in the area was calculated and taking rainfall intensity of 25mm/hr. with the return period of 2 years and design for 15 minutes time duration for the design purpose and at average annual rainfall for the overall potential of the area and Runoff coefficient is 0.85.

Rooftop Potential = Runoff Coefficient (0.85) x Intensity for 28 mm/ (15 min) x Area of Building. The Rain water harvesting potential for the selected building is shown in table 3. Administrative building was considered for implementation of rain water harvesting.

**Table 3-3: Rain water harvesting at Study Area**

| S.No. | RWH Potential Data of Project | |
|---|---|---|
| 1 | Mumbai Avg. Rainfall (in mm) | 2800 |
| 2 | LR Admin. Surface Area (in sqr. mtrs.) | 833 |
| 3 | Surface RWH Coefficient | 85% |
| 4 | RWH Potential Approx. (in KL) | 19.82 |
| 5 | Daily Rain fall potential (80-100 days of rainfall) approx. in KL | 15-20 |
| 6 | Rainfall at peak intensity approx. (in KL) | 17.5 |
| 7 | Re-charge structure required (no's) | 02 |
| 8 | Cost of water in lieu of Tanker supply (in lakh rupees) | 03 |
| 9 | Cost of RWH installation (in Lakh rupees) | 5.26 |
| 10 | Pay–Back Period (in years) | 2 |

**Design of RWH system implemented at Location in Mumbai Refinery**

It is a recharge structure specially designed keeping the Indian monsoon in perspective. Is a very effective system to recharge the groundwater levels thus helping to build your groundwater reserves. In built filtration media helps filter the rainwater before recharging the same. Creates a water column of 13ft, which helps create pressure on the water for faster disbursement into the recharge fractures. Made of pre-cast concrete rings, which makes it easy and fast to install. Bore hole for recharging is done till the water table level to help in better disbursement of the harvested rainwater. Consists of a de-silting chamber to trap all leaves, silt and other contaminants before they enter the recharge structure

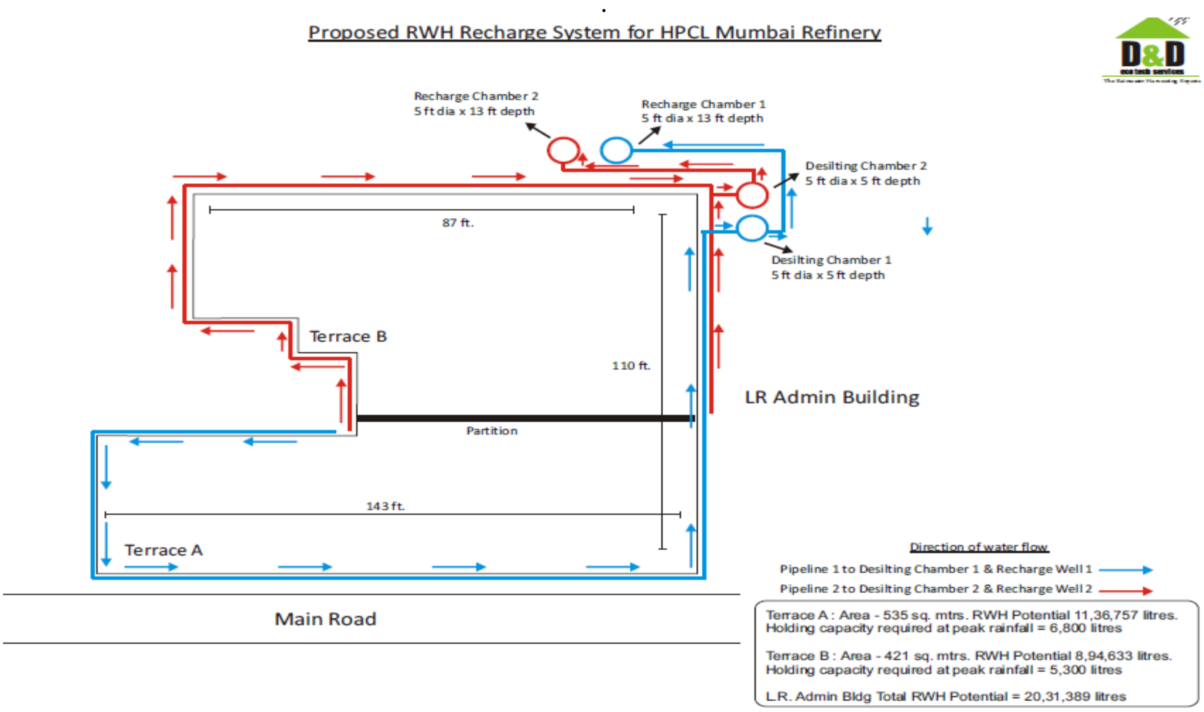


**FIG.2: Schematic of Rain Water ducting up to the re-charge pits**

**Fig.3**

**Water Table Fluctuation Method**

The water table fluctuation method was employed for computing rainfall recharge for pre monsoon and post monsoon for the following locations. This method is based on a water balance approach

| Well No | Lattitude | G.L | Water Level April 2016 | Water Level Sept 2016 | Water Level Fluctuation |
|---|---|---|---|---|---|
| LPG | X-1550.763<br>Y- 548.536 | 7.415 | 7.00 | 5.00 | 2.0 |
| Asphalt Plant | X-1199.6078<br>Y- 515.639 | 8.282 | 5.0 | 2.50 | 2.5 |
| FR(APS) | X-628.904<br>Y- 198.287 | 11.508 | 7.5 | 5.00 | 1.5 |
| Sub Station | X-628.904<br>Y- 198.287 | 12.566 | 8.0 | 5.5 | 2.5 |

| | | | | | |
|---|---|---|---|---|---|
| ISOM | X-480.042<br>Y-161.306 | 13.004 | 8.0 | 5.0 | 3.0 |
| GTG | X-1065.5654<br>Y-658.1 | 14.143 | 8.0 | 4.0 | 4.0 |
| DM Plant | X-616.50<br>Y-396.341 | 15.855 | 8.0 | 4.5 | 3.5 |
| HGU Plot | X-743.063<br>Y-642.646 | 17.407 | 8.0 | 6.5 | 1.5 |
| BIL Yard | X-316.189<br>Y-454.833 | 18.482 | 7.0 | 5.0 | 2.0 |
| Yard PRU | X-316.189<br>Y-454.833 | 19.492 | 7.5 | 6.0 | 1.5 |
| Ware House | X-316.189<br>Y-454.833 | 22.187 | 7.5 | 5.0 | 1.5 |
| Cooling Tower | X-316.189<br>Y-454.833 | 25.5 | 0.00 | 0.00 | 0,00 |

**Conclusion**

The rainwater harvesting is quantitative improvement by recharging the rainwater to the groundwater aquifers through bore hole drilled for the purpose. The water has excellent property to accumulate substances in soluble form as it moves over and into the land resource, from the biological processes and from human activities. The quantity analysis conducted on the groundwater samples collected during the month of April 2016 in pre monsoon period and in the month of November 2016, in the post-monsoon period reveals this truth of qualitative improvement of groundwater through rainwater recharge to the aquifers,Initially, before the Rainwater Harvesting, the water table at Mumbai Refinery was in the range of 6.5 m – 8.0 m and 2.5m – 7.0 m after rainwater harvesting The Depth to Water Table raised after the rainwater harvesting..It is observed that most of the Refinery area is having paved surface. There is no scope for percolation of rain water directly to the ground .The rainwater recharged to the aquifer will directly percolate rain water into the ground and dilutes the salt concentration in ground water. Therefore, in light of the present study, analysis and interpretations it can be concluded that the rainwater recharge improves the quantity of groundwater and depends upon the amount of rainwater recharged and the environment of rainwater collection and recharging.The rainwater harvesting structures are installed at few locations of HPCL Refinery. As per survey another 18 locations are identified for the Rainwater harvesting which is having potential to recharge. It is found that the ground water table was 0.95m to 1.8 m and by the year ground water available at 2.5m to 7.0m depth below existing ground level. the rainwater recharge improves the quantity of groundwater by improving water table depth. also, the available soil at HPCL refinery at shallow depth is Yellowish brown medium to dense silty sand which is having good characteristics to recharge groundwater. There is a urgent need for installation of Rain water Harvesting and aquifer to be recharged.

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