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RAINWATER HARVESTING WITH RECHARGE SHAFT AND PIT

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Abstract

Insufficient infiltration capacity of soil leads to water logging problems. In order to solve the problem of water logging in KBTCOE'S campus. Construction of recharge shaft and recharge pit successfully filters water and transmit it to depth of ground. However, by recharge shaft and recharge pit it can be solved successfully.

Artificial groundwater recharge is as for a water has increased awareness towards the use of process of induced replenishment of the ground water reservoir by human activities. The primary objective of this technology is to preserve or enhance groundwater resources in various parts of India which includes conservation or disposal of floodwaters, control of saltwater intrusion, storage of water to reduce pumping and piping costs, temporary regulation of groundwater abstractions, and water quality improvement by dilution by mixing with naturally- occurring groundwater (Asano, 1985). In such areas, there is need for artificial recharge of groundwater by methods such as water spreading, recharge through pits, shafts, wells and many more. The choice of a particular method is governed by local topographical, geological and soil conditions; the quantity and quality of water available for recharge; and the technological-economical viability and social acceptability of such schemes. This paper discusses various issues involved in the artificial recharge of groundwater.

Keyword: Shaft, Pit, Rainwater Harvesting.

1. Introduction

Project is consisting of Rainwater Harvesting & Recharge the Aquifers by using Recharge Shaft and Pit. In this particular project and required depth there is a hard strata and that's why water gets hardly particulate in this region, hence with the help of Resistivity meter survey we found the fractured zone at 78.5 feet to 85 feet beneath the ground depth. Hence to enhance and simplify the percolation of water we have provided the Recharge Shaft & Pits along with the drill hole of 85 feet deep till the fractured zone. Because of that hard strata we get while excavation, we provided 13 feet depth to the Recharge shaft. The drill hole we have taken is of 100 feet deep and in that till 20 feet from ground level there is casing pipe thoroughly has Small drill holes on pipe in concern to percolate more water & while up to the 20 feet from ground level there is layer of soil & murrum. To enter the surface runoff of rainwater into Recharge shaft and Pit we provided three layers of Boulders ,aggregates and wash sand to settle down the sediments coming with the rainwater.

The recharge of ground water occurs both naturally and artificially. The natural recharge occurs through the process of infiltration where the water percolates from the surface to the bed of the aquifer. But due to rapid development and stupendous growth of population in the recent past the areas for natural infiltration have been lessening day by day, hence the scope for natural recharge of the groundwater is also declining. In contrast to natural recharge (which results from natural causes); artificial recharge is the use of water to replenish artificially the water supply in an aquifer. Of all the factors in the evaluation of groundwater resources, the rate of recharge is one of the most difficult to derive with confidence. Estimates of recharge are normally subject to large uncertainties and spatial and temporal variability. The increasing demand artificial recharge to augment ground water supplies. Stated simply, artificial recharge is a process by which excess surface-water is directed into the ground either by spreading on the surface, by using recharge wells, or by altering natural conditions to increase infiltration to replenish an aquifer. It refers to the movement of water through man-made systems from the surface of the earth to underground water-bearing strata where it may be stored for future use. Artificial recharge (sometimes called planned recharge) is a way to store water underground in times of water surplus to meet demand in times of shortage. Some applications of artificial recharge are in wastewater disposal, waste treatment, secondary oil recovery, prevention of land subsidence, storage of freshwater within saline aquifers, crop development, and streamflow augmentation.

Problem Statement

- Rainwater causes water-logging problems. Water- logging causes various problems like runoff. Some of the biggest problem associated with Runoff is water-logging, at various places.
- Effectively Harvesting Rainwater from MVP's KBTCOE campus can reduce its. adverse effect to greater extent.

1.2 Objectives

- To Control the runoff from MVP's KBTCOE Campus (Ground) and recharge the aquifer.
- To Overcome water logging issues in MVP's KBT COE Campus (Ground).

2. Literature review

2.1 "A Groundwater Artificial Management Tool: Case Study of The Drava River In Maribor" Freewat Project 2020 FREEWAT's, the main impact will be most felt in enhancing science and in the participatory approach and evidence-based decision making in water resource management, hence, producing relevant and appropriate outcomes for policy implementation.

2.2 "A Review on Artificial Groundwater Recharge in India" SSRG International Journal of Civil Engineering 2016, In this paper, Artificial recharge of ground water should be licensed and controlled by competent authorities according to specific requirements laid down in an appropriate permit system that should be flexible to adapt to site- specific conditions. The question of ground-water exploitation should be clarified on a case-by-case basis, taking into account all relevant aspects, including ecological ones.

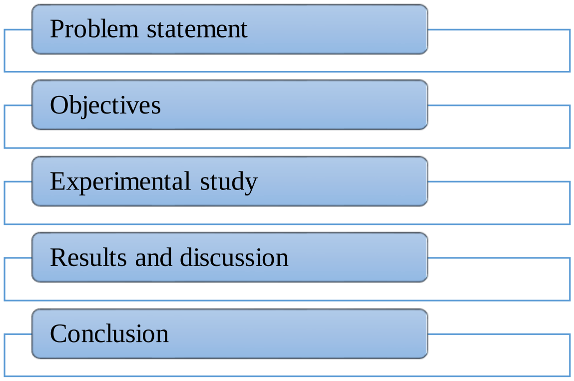
2.3 "Water logging problems in Egypt's Deserts: Case study Abu Mena archaeological site using geospatial techniques" Science Direct 2020, The present study indicates that since the initiation of the reclamation projects in West Al Nubariya area, the groundwater level has significantly increased in Abu Mena depression and has reached the ground surface forming several ponds, water bodies, soil salinization and deterioration of buildings including Abu Mena archaeological site. The water-bearing formation in this area is underlain by the Pliocene impervious sticky clay layer, which act as a barrier (seal) that prevents downward percolation of excess irrigation water.

2.4 "Seasonal Water logging Problem In A Mega City: A Study of Kolkata." Quest Journals Journal of Research in Humanities and Social Science 2016, presented study Water logging is become a severe problem in Kolkata metropolitan region with the increase of the high-rise buildings, which made the land congested and disrupted also. The sewerage and drainage system of the Kolkata is disrupting day by day due to unscientific land use system in the city. Mainly in the central portion of this metropolitan city‟s decreases the amount of open surface and there has created submergence due to ongoing high rises. So in this area badly affected in water logging situation after small downpour. Not only central part of K.M.C, Water logging is a persistent problem in different area of the Kolkata.

2.5 "Recharge Trench cum Recharge Shaft New Concept for Groundwater Recharge for Sustainability of source: A Case Study." International Journal of Current Medical and Applied Sciences 2015, Conducted study on, Sustainability of any source depends on the availability of water. The source of water may be groundwater or surface water. Majority of rural water supply schemes are based on groundwater and hence to enhance the sustainability of such water supply schemes, Groundwater Recharge becomes imperative, especially in case of over exploited areas. Artificial groundwater recharge is a process by which the groundwater reservoir is augmented at a rate exceeding the augmentation rate under natural conditions of replenishment.

3. Methodology

3.1 Flowchart:



Following are the steps:

- Conducting Contour Survey
- Conducting Profile Levelling survey
- Conducting Electrical resistivity survey
- Collecting Annual rainfall data
- Obtaining Maximum and Minimum Rainfall
- Calculating Surface Runoff
- Determining Runoff Collection Points
- Determining Dimensions of Recharge Pit and Recharge Shaft
- Fabrication

3.1.1 Contour Survey

Contouring in surveying is the determination of elevation of various points on the land and fixing these points of same horizontal positions in the contour map. A contour map is very useful since it provide valuable information about the land. Contour survey is carried out at the starting of any engineering project such as a road, a railway, a canal, a dam, a building etc.

3.1.2 Profile Levelling

Profile Leveling is used to establish changes in elevation along a line. Common lines requiring surveying are drains, roads, fences, and retaining walls. When this information is plotted on a graph, it will give a profile of the line and will enable one to establish grades, find high or low spots, and make estimates of depths of cuts and many other decisions. The following sections will illustrate the procedure for profile leveling and the preferred way to record the data.

Figure 1 Autocad Sheet of Contour Survey and Profile Levelling

3.1.3 Electrical Resistivity Survey

Electrical resistivity survey are one of a number of methods used for engineering geological investigations. In this type of survey electrical resistance meters are used to detect and map the subsurface, features and patterning. This survey is carried out to find depth of bedrock, to find out the thickness of soil, to find out electrical resistivity.

Table 1 True Resistivity and Rock Type and Layers of Strata

Strata / Layer	Resistivity	Depth (m)	Thickness (m)	Rock Type
L 1	10.56	0 – 2	2	Soil / Murrum
L 2	39.49	2 – 3	1	Hard Amygdaloidal Basalt
L 3	157	3 – 6	3	Compact Basalt
L 4	299.04	6 – 8	2	Very Less Fractured Compact Basalt
L 5	51.05	8 – 10	2	Very Less Fractured Compact Basalt
L 6	86.02	10 – 14	4	Very Less Fractured Compact Basalt
L 7	57.09	14 – 16	2	Very Less Fractured Compact Basalt
L 8	93.09	16 – 20	4	Very Less Fractured Compact Basalt
L 9	52.34	20 – 22	2	Very Less Fractured Compact Basalt
L 10	78.5	22 – 24	2	Very Less Fractured Compact Basalt
L 11	-8	24 – 26	2	Fractured Basalt

3.1.4 Rainfall Data

Annual Rainfall data is needed to Determine the size of recharge pit. From the peak rainfall successfully harvested rainwater is calculated from runoff and deducing evaporation and infiltration losses.

Annual Rainfall data is obtained from Meteorological Department,Meri.

3.1.5 Obtaining Maximum and Minimum Rainfall

Obtaining minimum and maximum rainfall data is needed to determine maximum and minimum runoff.

3.1.5 Surface Runoff

Surface runoff always occurs when the access of water to the ground surface is higher than the infiltration capacity of the soil.

The Rational Method Equation -

The surface runoff is calculated by Rational formula.

The equation that is the centerpiece of the Rational Method is: q = CxIxA, where q is peak surface runoff rate in cfs, from a watershed of area, A acres, and runoff coefficient, C, due to a storm of intensity, i in/hr. The units on peak runoff rate, q, are actually acre-in/hr.

3.1.6 Recharge Shaft and Pit

Depth of the recharge pit is 13 feet, consisting layer boulders of 3feet depth from bottom of recharge pit, from layer of boulder that is above 3 feet from recharge pit another layer of filter media consisting 40 mm of aggregate of 3 feet.

Above this layer there is filter media of 4 feet of fine sand remaining 3 feet of space is there for settling of the water Relatively clean water gets into shaft.

Recharge shaft is placed in recharge pit surrounding the filter media.

The depth of bore drill is 100 feet.

The casing pipe is placed upto 25 feet with the holes that water can travels from shaft into it.

4. Data collection and processing

Nashik is a city located on the Northwestern part of Maharashtra, INDIA. It is one of the most dynamic cities of India with one of the fastest growth rates due to immigration from various parts of other states of India. Nashik is one of the cleanest cities of India and is also known by several other names like "RAM BHUMI”. The city is situated on the banks of the Godavari river. Nashik has mythological, historical, social and cultural importance. Nashik is well known for being one of the Hindu pilgrimage sites of the KUMBH MELA , which is held in every 12 years. The city is famous for Grapes and Wineries. The city called “Wine Capital of India”.

4.1 General Information of Nashik City

Table 2Information of Nashik City

Country	India
State	Maharashtra
District	Nashik
Latitude	19.9975°N
Longitude	73.7898°E
Height above sea level	584 m
Coordinates	19.9975°N,73.7898°E
Population	14,86,053 (2011)
Langauges	Marathi, Hindi, English
Area	267km²

4.2 Rainfall Data

The normal rain fall of the Nashik can be considered at 1232 mm with average number of 45 rainy days. The main monsoon period in study area is ranging from June to September. Runoff is calculated from rainfall data is 35m³ for College playground.

Table 3 Average Monthly Rainfall Data of Nashik City in mm

Month	2016	2017	2018	2019	2020
January	0 mm	0 mm	0 mm	0 mm	0 mm
February	0 mm	0 mm	0 mm	0 mm	0 mm
March	0 mm	0 mm	0 mm	0 mm	0 mm
April	0 mm	0 mm	0 mm	0 mm	0 mm
May	0 mm	0 mm	0 mm	0 mm	0 mm
June	0.6	11.04 mm	4.52 mm	4.24 mm	8.43 mm
July	16.30 mm	16.45 mm	9.51 mm	16.38 mm	3.1 mm
August	14.14 mm	4.90 mm	3.51 mm	13.87 mm	8.23 mm
September	1.90 mm	3.44 mm	2.03 mm	6.07 mm	4.63 mm
October	4.2 mm	3 mm	0 mm	3.48 mm	2.87 mm

Table 4 Monthly Rainfall Data of Nashik City

Month	2016	2017	2018	2019	2020
January	0 mm	0 mm	0 mm	0 mm	0 mm
February	0 mm	0 mm	0 mm	0 mm	0 mm
March	0 mm	0 mm	0 mm	0 mm	0 mm
April	0 mm	0 mm	0 mm	0 mm	0 mm
May	0 mm	0 mm	0 mm	0 mm	0 mm
June	18 mm	331.2 mm	135.6 mm	127.2 mm	252.9 mm
July	489 mm	493.5 mm	294.3 mm	491.4 mm	93 mm
August	424.2 mm	147 mm	105.3 mm	416.1 mm	246.9 mm
September	57 mm	103.2 mm	60.9 mm	182.1 mm	138.2 mm
October	126 mm	90 mm	0 mm	104.4 mm	86.1 mm
November	0 mm	0 mm	0 mm	0 mm	0 mm
December	0 mm	0 mm	0 mm	0 mm	0 mm

4.3 Calculations

The quantity of water to be recharge is calculated as follow. Then number of pits which is required to manage surface water are encountered for proposed site. From analysis part, further calculation is carried out to determine the size of pit and Pit capacity.

For Concrete Surface: -

a) Volume of Rainfall over the roof of 2 building of college = Area of Plot × AnnualRainfall
b) Effectively Harvested water from rainfall = 3721.32 × 0.80 × 0.85 = 2530.5m³ Take, Coefficient for roof = 0.85
Coefficient for evaporation = 0.80

For Playground: -
Volume of rainfall over the Plot or Playground = 1.232 × 4000 = 4928m³

Effectively Harvested rainwater = 4928 × 0.35 × 0.80 = 1379.84m³Take, Coefficient for Playground = 0.35

Coefficient for evaporation = 0.80

Total rainwater effectively harvested = 1379.84 + 2530.5 = 6307.84m³

Design of Pit: -

The capacity of Pit = A × r × c

Where, A= Surface area of roof top catchment

r= Peak rainfall in 15 min. = (Assuming 25mm) = 0.025m

Tank capacity for Concrete Surface = 3020.552 × 0.85 × 0.025 = 64.19m³Tank capacity for Playground = 4000 × 0.35 × 0.025 = 35m³

Total Pit Capacity = 64.190m³ + 0.025m³ = 99.19m³ ~ 100m³

Table 5 Calculations for Find Rock Type with Resistivity Readings

Sr. No.	A	R	1/R	2πa	2πaR
1	1	1.998	0.500	6.283	12.55
2	2	1.188	0.841	12.566	14.92
3	3	1.00	1	18.84	18.84
4	4	0.995	1.005	25.12	24.99
5	5	0.981	1.019	31.4	30.80
6	6	0.900	1.12	37.68	33.91
7	8	0.860	1.162	50.24	43.20
8	10	0.710	1.408	62.8	44.588
9	12	0.650	1.538	75.36	48.98
10	14	0.585	1.70	87.92	51.43
11	16	0.520	1.92	100.48	52.24
12	18	0.485	2.06	113.04	52.82
13	20	0.455	2.19	125.6	57.148
14	22	0.410	2.43	138.16	56.645
15	24	0.385	2.59	150.72	58.027
16	26	0.975	1.02	163.28	159.198
17	28	0.914	1.094	175.84	160.717
18	30	0.755	1.32	188.4	142.24

Formula for Find True Resistivity:

$\rho = (\Delta x \div \Delta y) \times 6.28$

ρ1 = (2 ÷ 0.841) × 6..28 = 10.56	ρ2 = (1 ÷ 0.159) × 6.28 = 39.49
ρ3 = (3 ÷ 0.12) × 6.28 = 157	ρ4 = (2 ÷ 0.042) × 6.28 = 299.04
ρ5 = (2 ÷ 0.246) × 6.28 = 51.05	ρ6 = (4 ÷ 0.292) × 6.28 = 86.02
ρ7 = (2 ÷ 0.22) × 6.28 = 57.09	ρ8 = (4 ÷ 0.27) × 6.28 = 93.03
ρ9 = (2 ÷ 0.24) × 6.28 = 52.34	ρ10 = (2 ÷ 0.16) × 6.28 = 78.5
ρ11 = (2 ÷ (-1.57)) × 6.28 = -8	ρ12 = (2 ÷ 0.074) × 6.28 = 169.72
ρ13 = (2 ÷ 0.226) × 6.28 = 55.57	

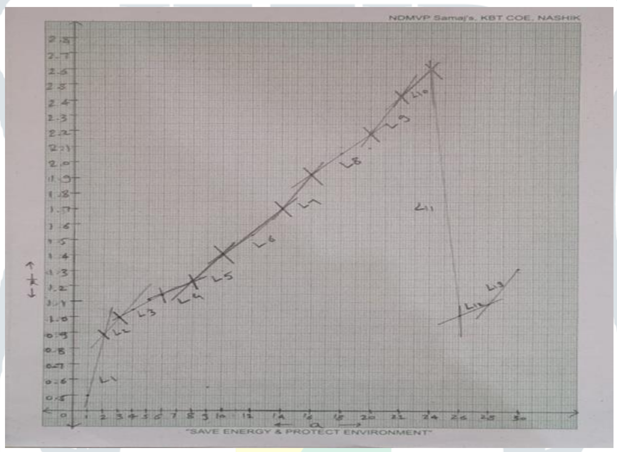


Figure 2 Graph of Resistivity Survey for Layers of Rock

4.4 Lithology of Site

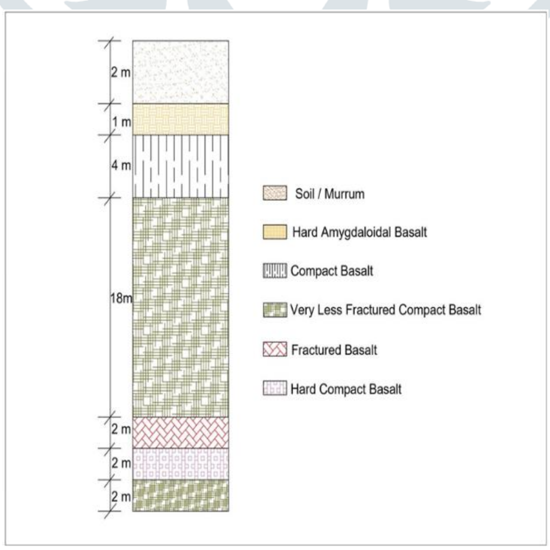


Figure 3 Lithology of Site

- 2 meter Strata or Layer of Soil and Murrum at G.L. to 7 feet
- 1 meter Strata or Layer of Hard Amygdaloidal Basalt Rock at 7 feet to 10 feet
- 4 meter Layer of Compact Basalt at 10 feet to 27 feet

- 18 meter Layer of Very Less Fractured Compact Basalt at 27 feet to 78.5 feet
- 2 meter Strata of Fractured Basalt Zone at depth 78.5 feet to 85 feet
- 2 meter Layer of Hard Compact Basalt 85 feet to 92 feet
- 2 meter Layer of Very Less Fractured Compact Basalt 92 feet to 100 feet

4.5 Hydrological Aspect for Groundwater Recharge

Storage of water within the earth's crust is dependent upon geological processes that have produced voids capable of absorbing, transmitting, storing, end yielding water. Voids are numerous in most each material. Some are large enough to transmit water freely, whereas others. are so small that surface tension exceeds hydrostatic pres3res and the transmission of water is prevented. Useful ground-water storage capacity is not measured by the porosity of the reservoir but rather by the amount of water that the reservoir will yield by gravity drainage. This is commonly termed specific yield. It is the difference between porosity and field moisture capacity. Potential aquifers below the zone of soil moisture are already at field capacity. Therefore, most of the recharged water either can be recovered or will move to natural discharge areas.

The following factors must be considered in selecting the proper location of sites for artificial recharge :

a) Water (availability, source, turbidity, quality, etc.)
b) Surface soils
c) Depth to aquifer
d) Geologic structure and capacity of the ground-water reservoir
e) The presence of aquicludes
f) Movement of ground water

An investigation to determine the location, extent, permeability and other physical characteristics of the surface end the various underlying strata is needed to select the site best adapted to artificial recharge. The greatest volumes and rates of recharge are possible in thick formations of pervious sands end gravels or porous end cavernous rocks.

4.6 Location of Site

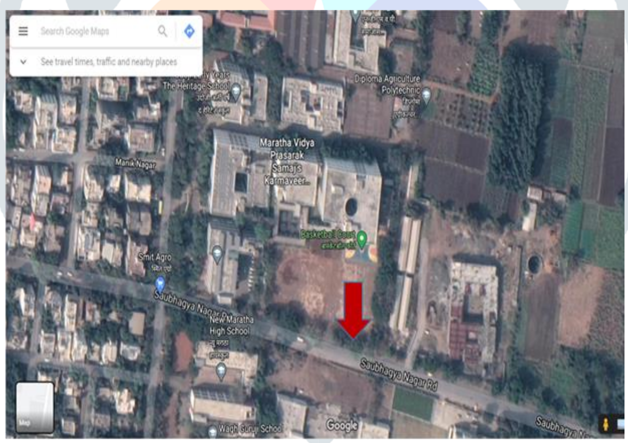


Figure 4 Location of Site

4.7 Section of Shaft and Pit

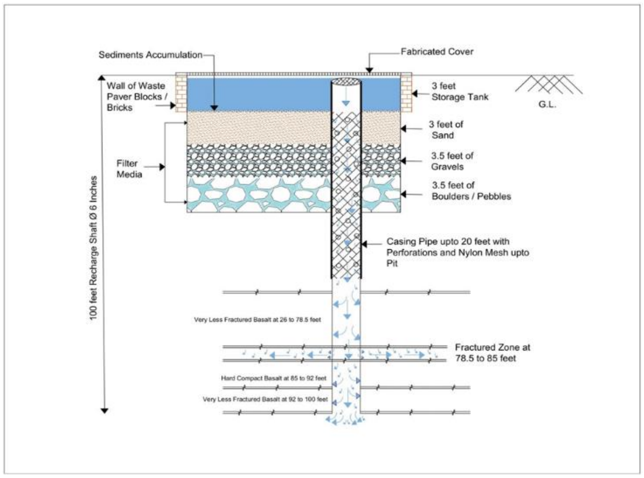


Figure 5 Section of Recharge Shaft and Pit

Description of Section :-

Shaft is drill upto 100 feet and Pit is excavated around the shaft size of 6ft * 6ft into length to breadth and height upto 13 feet. Casing Pipe is set upto the 25 feet in shaft with 6 inches pipe with the holes to percolate the water. Material is filling in the pit with the layers. From the bottom of pit 1st layer is boulder upto 3 feet. 2nd layer is Aggregate upto 3 feet. 3rd layer is sand upto 4 feet.and rest of part is open upto 3 feet to set the water and it goes into the shaft.

4.8 Recharge Shaft and Pit on Site

Figure 6. Recharge Shaft and Pit on Site

Figure 7 Material Filling in Pit

Figure 8 Material Filling Layers in Pit

5. Design of recharge shaft and pit

The overall objective of the design is to create a structurally stable, long-lasting, efficient recharge shaft and pit that allows surface water to move effortlessly and sediment-free from the surface to confined aquifers. Therefore, wells are of desired volume and quality, and prevents bacterial growth and material decay within the well.

5.1 Components of Recharge Shaft and Pit

- 100 feet bore drill as a shaft
- PVC Casing pipe upto 25 feet with holes
- PVC Casing pipe size 6 inches
- Rainwater to drain
- Filter media of boulders , gravels , aggregates , sand
- 1 no.Pit size 6ft * 6ft * 13 ft and 4 no. of pits size 4ft * 4ft* 4ft
- Brickwork to Pit
- Fabrication of mesh to avoid Debris and accidents.

5.2 Calculation for Pit Structure

The quantity of water to be recharge is calculated as follow. Then number of pits which is required to manage surface water are encountered for proposed site. From analysis part, further calculation is carried out to determine the size of pit and Pit capacity.

For Concrete Surface :-

c) Volume of Rainfall over the roof of 2 building of college = Area of Plot × AnnualRainfall
d) Effectively Harvested water from rainfall = 3721.32 × 0.80 × 0.85
= 2530.5m³ Take, Coefficient for roof = 0.85
Coefficient for evaporation = 0.80

For Playground: -

c) Volume of rainfall over the Plot or Playground = 1.232 × 4000 = 4928m³
d) Effectively Harvested rainwater = 4928 × 0.35 × 0.80 = 1379.84m³ Take, Coefficient for Playground = 0.35
Coefficient for evaporation = 0.80
Total rainwater effectively harvested = 1379.84 + 2530.5 = 6307.84m³

Design of Pit :-

The capacity of Pit = A × r × c

Where, A= Surface area of roof top catchment

r = Peak rainfall in 15 min. = (Assuming 25mm) = 0.025m

Tank capacity for Concrete Surface = 3020.552 × 0.85 × 0.025 = 64.19m³Tank capacity for Playground = 4000 × 0.35 × 0.025 = 35m³

Total Pit Capacity = 64.190m³ + 0.025m³ = 99.19m³ ~ 100m³

6. Result and conclusion

Result

Project is consist of Rainwater Harvesting & Recharge the Aquifers by using Recharge Shaft and Pit. In this particular project and required depth there is a hard strata and that's why water gets hardly particulate in this region , hence with the help of Resistivity meter survey we found the fractured zone at 78.5 feet to 85 feet beneath the ground depth . Hence to enhance and simplify the percolation of water we have provided the Recharge Shaft & Pits along with the drill hole of 85 feet deep till the fractured zone. Because of that hard strata we get while excavation , we provided 13 feet depth to the Recharge shaft . The drill hole we have taken is of 100 feet deep and in that till 20 feet from ground level there is casing pipe thoroughly has Small drill holes on pipe in concern to percolate more water & while up to the 20 feet from ground level there is layer of soil & murrum. To enter the surface runoff of rainwater into Recharge shaft and Pit we provided three layers of Boulders ,aggregates and wash sand to settle down the sediments coming with the rainwater .

The Recharge Shaft is deep upto the 100 feet and Pit is 2m × 2m × 4m in size and its Recharge Capacity is 35 cubic meter = 35000 liters water.

Rainfall is considered as 1232 mm per year.

Catchment Area is Considered 4000-meter square.

Total Runoff is 1379.84 cubic meter = 1379840 liters Recharge into the Ground.

Conclusion

Artificial recharge of ground water should be licensed and controlled by competent authorities according to specific requirements laid down in an appropriate permit system that should be flexible to adapt to site-specific conditions. The question of ground-water exploitation should be clarified on a case-by-case basis, taking into account all relevant aspects, including ecological ones. The relevant regulations should establish the extent to which exemptions are allowed. There is a need for further research and development of artificial recharge techniques for a variety of conditions. In addition, the economic, managerial and institutional aspects of artificial recharge projects need to be studied further.

Thus it can be concluded that the artificial recharge of groundwater gives the reduction of runoff, increased availability of groundwater and solve the water logging issue in our MVPS's KBT College ground and recharge the aquifer.

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