International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

Recharge of Groundwater using Abandoned Mine Pits with Treated Wastewater

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Abstract: ***Availability of water is undisputedly one of the most critical components for sustaining alleconomic activities. There is an urgent need to consideraugmenting the existing water source by recycling and reusing high quality treated effluent from existing wastewater treatment plants (WWTPs) to meet the on-going as well as future water demand of the growing population. The broad objective of this paper is to assess the recharge potential of abandoned mine pits and establish the feasibility of artificial recharge to groundwater via water spreading method also ensuring the quality of source water for recharge. 10 MLD Tertiary Treatment Plant (TTP) having effluent BOD less than 2 mg/l is identified for recharge of abandoned mine pits in south Delhi. Subsequently, the treated source water is to be collected in the sump of the proposed pump house and pumped through the transmission main to the mine pits site and distributed equally through a proposed distribution network to all the fourteen pits.***

Keywords: Artificial Groundwater recharge, wastewater effluent, Mine pits

1. Introduction

The ever increasing demand for water for NCT Delhi is a severe concern to planners and administrators. The water requirement is growing at a rapid pace, mainly due to the ever-increasing population and its associated demands.The grave groundwater situation has caught the attention of the planners and groundwater professionals to suggest remedial actions for the conservation and recharge to groundwater. With the use of advance engineering technologies of recharging groundwater, the large volumes of wastewater effluent that otherwise remain unutilised can beused to recharge aquifers.

1.1 Study Area

The study area lies to the north of Gurgaon- Faridabad Toll road, which also forms the boundary between Haryana and Delhi State. The Toll Road coincides with the surface water divide of the area which sheds run-off water on either side of the Ridge. The area of study lay in the northern part of a Toll road and abandoned mine pits are located on either side of water divide. 14 nos. Pitshave been considered in the study area. Location of the abandonedmine pits in the project area is shown in Fig 1.

Figure 1: Study Area

2. Data Collection

Following data was collected to establish a workable scheme.

2.1 Capacity of Mine Pits

Volume and basal area of each pit calculated from the contour map areas given in Table 1.

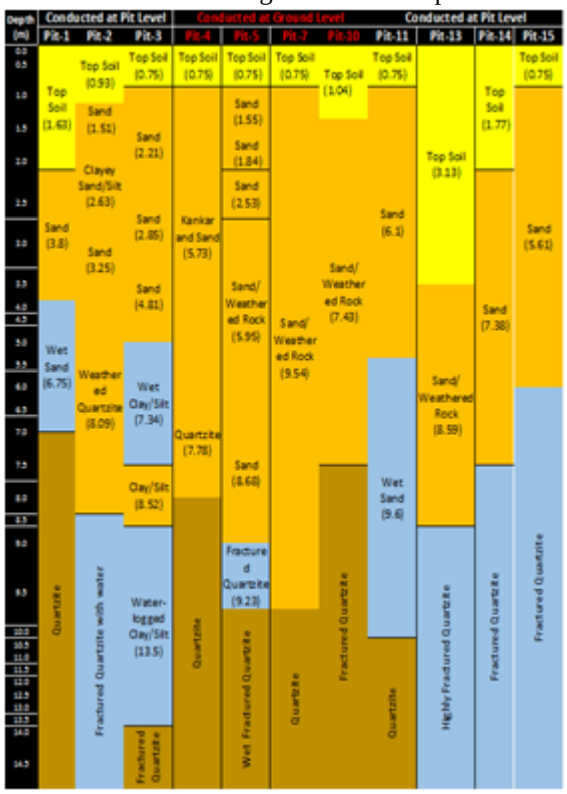
Table 1: Area and Volume of Mine Pits

Pit No.	Total Volume of Pit (Cubic Metre)	Bottom Spread Area(Sqm)
1	2,80,990.3	12,550.17
2	8,73,531.5	38,723
3	1,75,372.9	5,575
4	10,42,578	24,176
5	5,49,356.2	16,442
6	69,340.1	6,198
7	28,018.5	899
8	5,44,147	9,661
9	25,627	982
10	28,827.8	1,054
11	4,33,315.8	14,871
12	57,141.7	1,789
13	4,76,536.4	7,102
14	32,54,389.9	37,485
Total Volume	78,39,173.10	

2.2 Soil Infiltration Test

Based on the double ring infiltrometer test, the infiltration rates for the pits are 2 mm/hr for hard quartzite and 4 mm/hr for weathered to highly weathered quartzite. Composition of Strata in various pits is as given in Table 2:

Table 2: Underground strata of pits



2.3 Direction of Groundwater Flow

Most abandoned mine-pits occur close to the Ridge–crest occupied by Quartzite rock formation. The direction of the groundwater flow follows the topography of the land and is towards the north and northeast. Local variations in groundwater flow direction are also observed.

3. Activities Conducted

3.1 Underground water quality of the downstream area

We collected the water samples from the downstream areawhich is likely to be recharged from this scheme. The test results of water sampleisgiven in Table 3.

Table 3: Water quality data of nearby villages to pits

Parameter	Sample 1	Sample 2	Sample 3	Sample 4
BOD	<0.4	<0.4	<0.4	<0.4
Turbidity	0.3	0.2	0.3	0.5
pH	7.46	0.76	7.01	7.12
Chloride	34.71	81.08	85.76	79.12
TDS	326	386	442	542
Fluoride	0.21	0.28	0.35	0.73
Total Alkalinity	275.94	275.94	275.94	325.92
Iron	0.5	0.2	0.2	0.11
Nitrate	10.87	15.59	12.66	25.42

3.2 Water Quality Sampling of STP effluent

As a source water for recharging, we proposed to utilise the tertiary treated effluent from STP of nearby area. To ascertain the feasibility of its usage, we collected the water sample from the effluent channel of the STP. The sample was sent to the laboratory and water quality results obtained are given in Table 4.

Table 4: Water quality data of source water

S.No.	Item	Data
1	BOD (mg/l)	1
2	Turbidity (NTU)	1.25
3	pH	7.7
4	Chloride (mg/l)	120
5	TDS (mg/l)	599
6	Total Alkalinity (mg/l)	240

As the water quality results of the source water were approximately compatible to the native targeted area of recharge, the proposed proposal was accepted. Thus, the 10 MLD plant producing treated effluent with BOD around 1 mg/l was identified for recharge of abandoned mine pits.

3.3 Soil-Aquifer treatment (SAT)

After studying the quality of recharge water, we proposed that recharge in mine pits will bedone using the water spreading method of recharge in order to avoid any chance of contamination. Artificial recharge is the process of spreading or impounding water on the land to increase the infiltration through the soil and percolation to the aquifer. The underground formations will act as natural filters to remove any physical, biological, and chemical pollutants from the water as it moves through. Often, the quality improvement of the water is the main objective of recharge, and the system is explicitly operated using the soil and the aquifer to provide additional treatment to the source water. Techniques used in this way are called soil-aquifer treatment (SAT), or geo purification, systems.

On investigation of mine pits, it was found that subsoil strata of pits consist of 4 - 5 m sand which will allow infiltration through the soil before recharging the groundwater. Infiltration–percolation allows oxidation and disinfection of the water to occur. This process will work as a further treatment to reduce BOD, if present.

3.4 Estimation of Recharge Water

We have estimated the volume of recharge water required for storage in pits based on the geotechnical investigations of the pits.Total volume of mine pits is given in Table 5.

Table 5: Volume of Recharge Water

Pit no.	Area of water spread (m^2)	Permeability of underlying rock strata m/day	Volume of recharge water m^3/day
1	12550.00	0.048	602.40816
2	38723.0	0.096	3717.408
3	5575.0	0.096	535.2
4	24176.0	0.048	1160.448
5	16442.0	0.096	1578.432
6	6198.0	0.096	595.008
7	899.0	0.048	43.152
8	9661.0	0.048	463.728
9	982.0	0.096	94.272
10	1054.0	0.096	101.184
11	14871.0	0.048	713.808
12	1789.0	0.048	85.872
13	7102.0	0.096	681.792

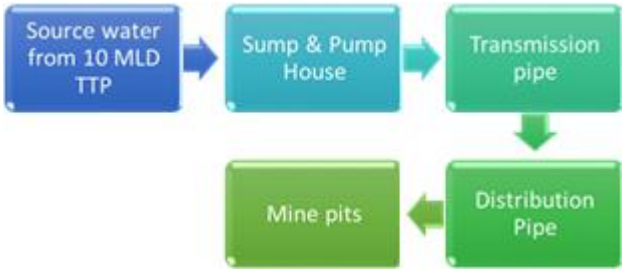
14	37485.0	0.096	3598.56
Grand Total		13,971.2722 m^3/day Say – 14,000 m^3/day (14 MLD)	

4. Project Proposal

The project proposes to obtain 10 MLD tertiary treated sewage effluent from the STP. Thus 10 MLD of source water shall be collected in the sump of the proposed pump house and pumped through the transmission main to the mine pits site and equally distributed through a proposed distribution network to all the fourteen pits. The project framework, consistent with the proposals mentioned above comprises the following components:

The project frameworkcomprises the following:

- Planning and design of Sump and Pumphouse
- Design of Pumping Machinery
- Planning and design of Transmission pipe
- Planning and design of Distribution network



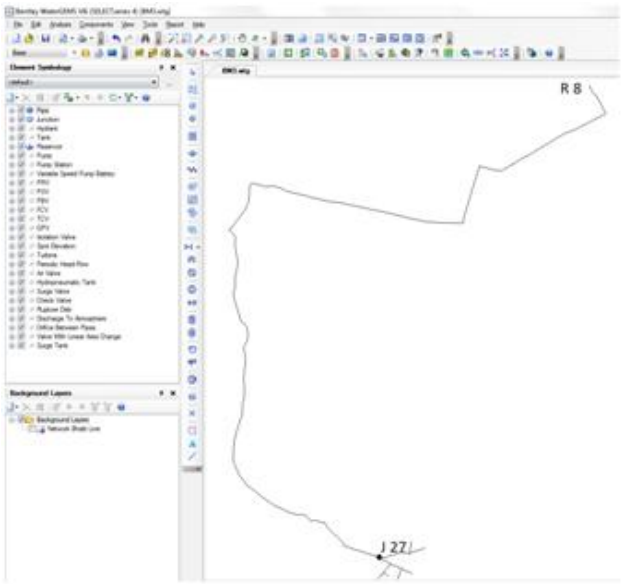


Figure 2: Pipe alignment from Source (R8) to Pits(A)

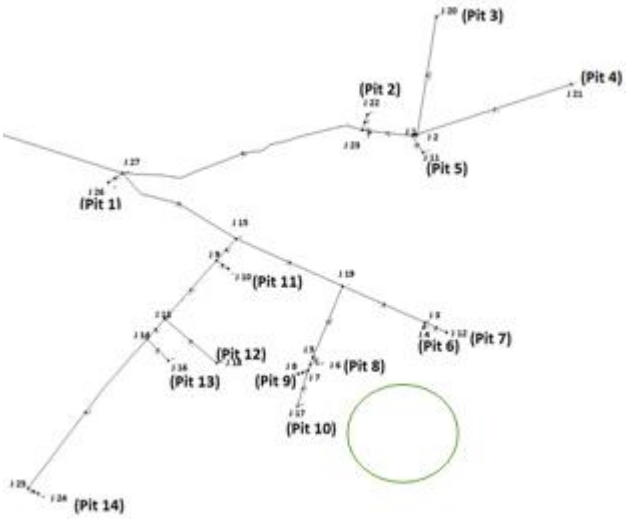


Figure 3: Pipe Distribution to 14 pits ('A' part)

5. Conclusions

The utilisation of open abandoned mine pits can be a good option for rainwater harvesting and groundwater recharge. This process will not only replenish groundwater but also utilise the abandoned mine pits which can otherwise also be used as a waste disposal site. Additionally, tertiary treated effluent should also be viewedas resource water rather than treating it as a nuisance. Apart from recharging aquifer, low-quality effluent can also be used for various other nonpotable purposes.

6. Data Availability Statement

The data used in the preparation of the journal is not collected from secondary report or data. The data has been collected after surveys & investigations conducted on the study area. Therefore, some or all data, models, or code generated or used during the study are proprietary or confidential in nature and may only be provided with restrictions.

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