URBAN STORM WATER MANAGEMENT THROUGH ARTIFICIAL RECHARGE AND IMPROVEMENT IN GROUNDWATER REGIEME

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Abstract: - The storm water during rainy season causes drainage problem and often roads are damaged by rainfall runoff. This problem is serious in big cities and number of industries, where most of the open area is covered by roads or some concrete structures without proper drainage. The water on roads during rains remains stagnant for hours together due to poor storm water management and results into erosion of roads. Our major cities & industrial areas are facing water crisis due to over exploitation and declining water levels. The paper deals with the solution of managing storm water on roads/paved area in industries and channlizing the same to ground water system in hygienic manner based on hydroinformatics in terms of rainfall pattern, rainfall intensity and recharge capacity of sub-surface hydrogeological formations (CGWB). In this project, infiltration recharge systems through Soil Aquifer Treatment system (SAT) technology may be adopted (Bouwer Herman, USA). The technology is used innovatively through the vadose zone which purifies most of road impurities before meeting ground water. The recharge structures should be provided with inverted filter and Chemical ingredients like Charcoal to negate effect of oil & Greece and the impurities likely to be present on busy road and paved areas as further precautionary measures. These ingredients are in addition to usual filter media. The monitoring well should also be made to evaluate long term benefit of the project in terms of improvement of quality of water and water levels. The concept would not only help in controlling devastating effects of storm water but would also improve quality of water and increase life of roads due to minimum damage to road by runoff water and reduction in cost on maintenance & repair of the road. The storm water management and artificial recharge to ground water is sustainable in long term, if periodical maintenance like replacement of silt from storage chamber & change of upper coarse sand and chemical ingredients in filtration chamber before monsoon. The main strength of the concept is in its replication as it can be adopted on all roads of urban sector after taking it as pilot project for smart cities to be developed.

Key-Words: - storm water, drainage, runoff, water levels, hydro informatics, aquifer, vadose zone, monitoring well , artificial recharge

1 Introduction

The storm water during rainy season causes drainage problem and often roads are damaged by rainfall runoff. This problem is serious in big cities and industries, where most of the open area is covered by roads or some concrete structures without proper drainage. The water on roads during rains remains stagnant for hours together due to poor storm water management and results into erosion of roads. In our country, industries and cities are facing water crises due to over exploitation of under ground water and no provision for recharge of aquifers. Declining water levels are also consuming more energy in lifting the water and reduction in green coverage. Solution of managing storm water on roads in urban and industrial areas is channelizing the same to ground water system in hygienic manner. This method not only helps in controlling the devastating effects of storm water, but would improve ground water regime both in terms of rising of water levels and increase in ground water availability. The techniques will also increase life of roads and reduce cost on maintenance and repairs. Besides, better plant growth is envisaged with less water requirement due to moist condition of surface soil

2 Methodology

In designing rainwater-harvesting system for artificial recharge of ground water, capturing rainfall run off from the roads and creating artificial connectivity to sub surface water in the hygienic manner is the key concept. The effectiveness of the concept lies in reasonable cost, coverage of large areas and immediate implementation and immense benefits in terms of additional water availability, improvement in water quality, increased plantation, maintaining eco-balance, reducing the cost on maintenance and repairs of roads and many fold increase in life of the roads.

Storm water harvesting along both the sides of roads with the help of suitable, simple structures, would not only control storm water hazards in through percolation structures. The concept may be made essential for smart cities to be developed after pilot project is initiated.

cities, but will enhance ground water availability 8 to 10 times compared to natural process of rainfall infiltration. The location and design of sustainable storm water harvesting system require hydro geological study of the area as well as sub surface information of most permeable zone. Besides, average rainfall and rainfall intensity need to be analyzed as per climatic zones . Based on normal rainfall and peak rain fall intensity, the storm water harvesting system is designed in such a way that 70-80 % runoff of roads and paved area is sent back to ground water regime after natural filtration process based on Rate of Recharge after Recharge Test on existing wells/pits. (Jain, Dr. S. K.). The Recharge test plot is shown in **Fig. 1**.

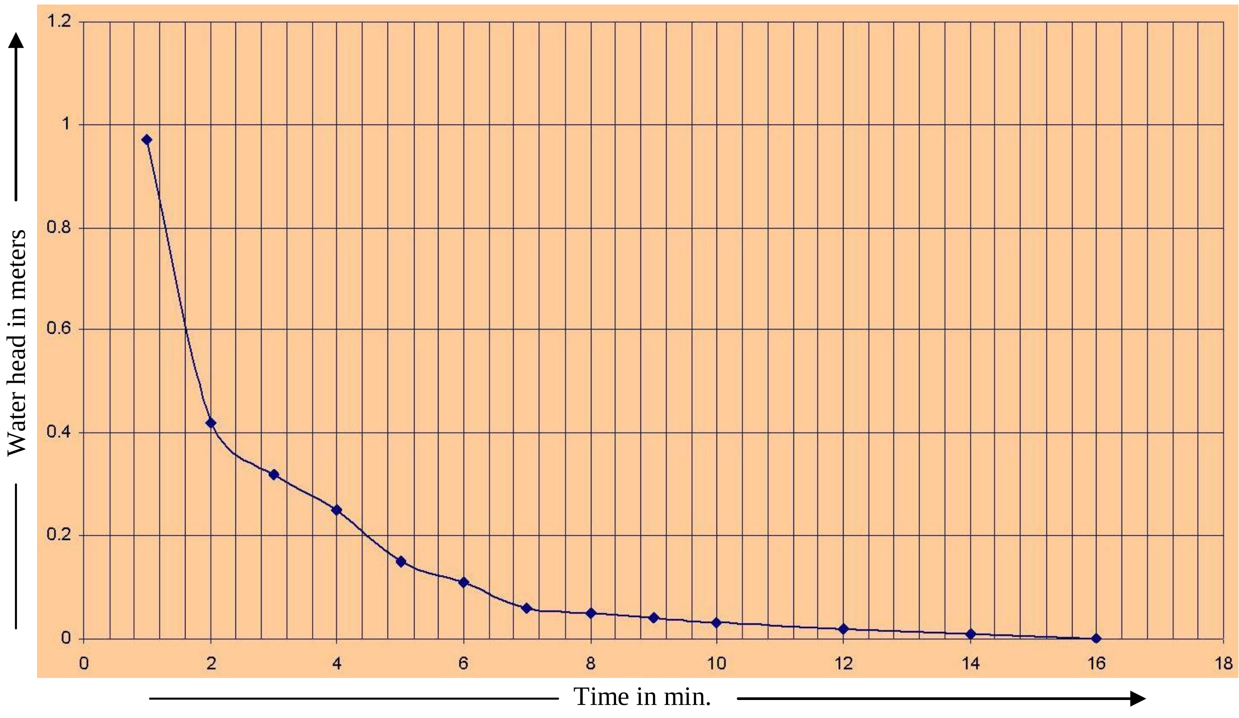

Fig.1

3 Design

3.1 The area with soil/weathered rock having vertical permeability up to water level zone:

In this kind of situation, the percolation pit method would be suitable. In this method, the pits of suitable dimensions can be made along the roads between side lanes and main road. These pits may be made along both sides of the road at suitable interval based on estimated runoff as shown in Fig. 2. The pits should have natural filtration media of coarse sand, gravels and pebbles and should be covered with perforated slabs. The road should have suitable slopes towards these pits from the divider.

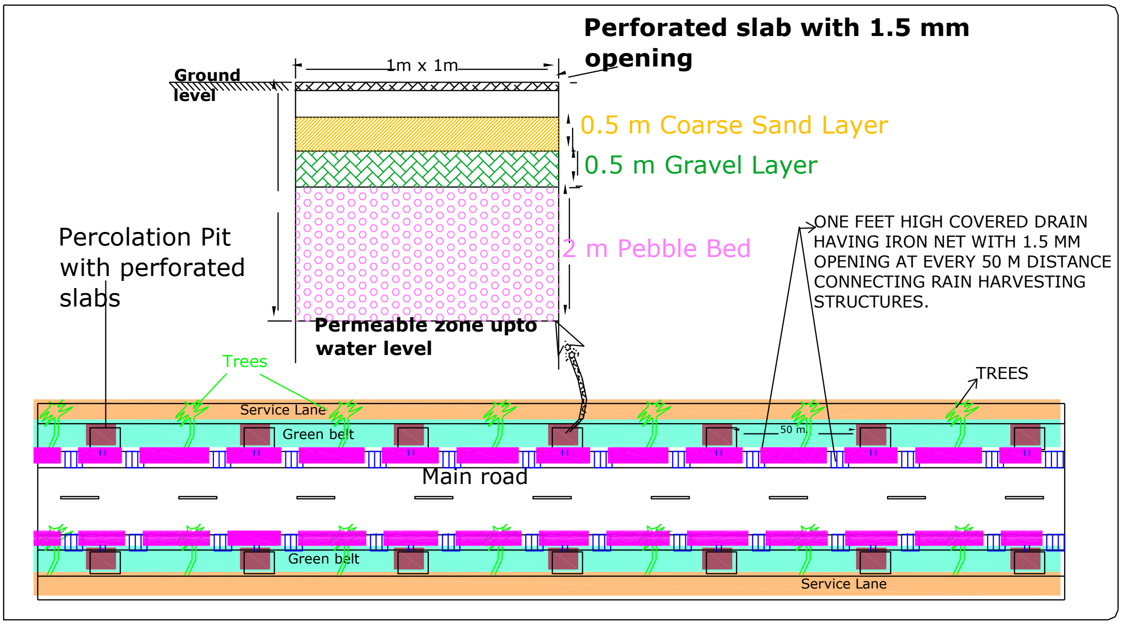

Fig.2

3.2 The area having impermeable zones prior to water level, like clays, solid rocks etc

In this type of areas, the rainwater harvesting system will have recharge shaft via storage tanks and filtration tanks reaching 10 to 15 meters above water level. The design is self explanatory as per Fig. 3. Here, water is diverted to ground water reservoir through recharge shaft via filtration media crossing the impermeable zone.

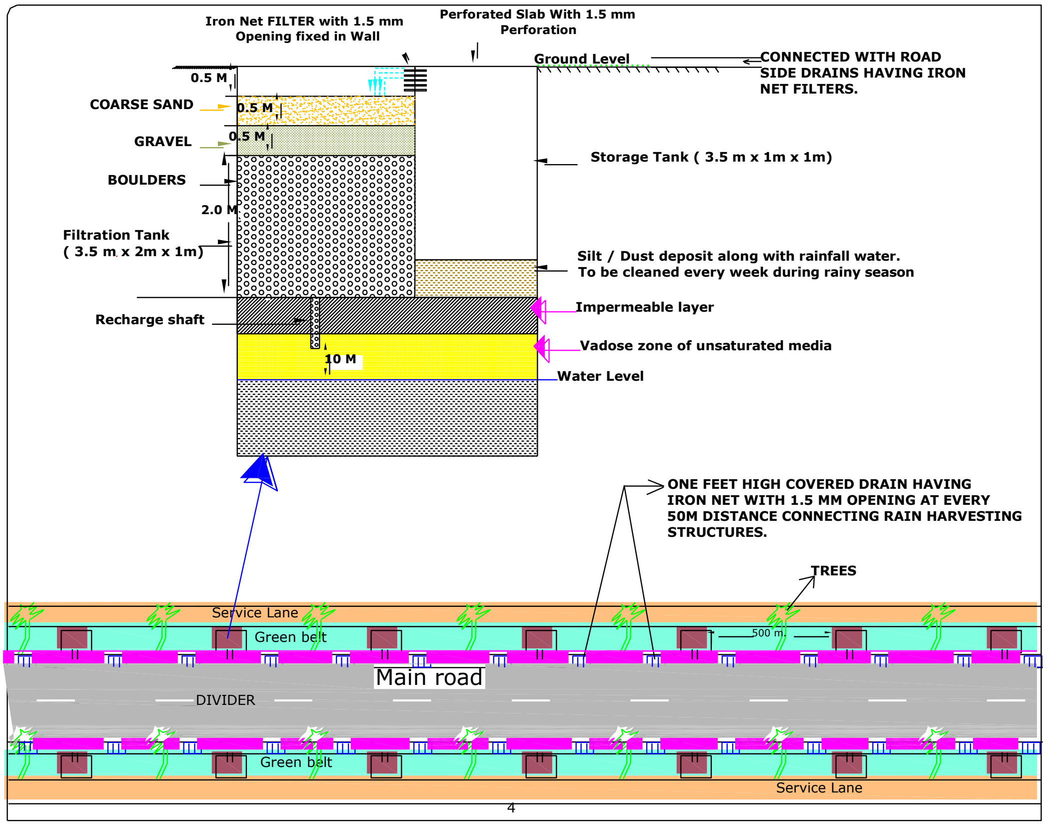

Fig.3

4 Removal of Pollutants

The percolation structures have been designed with sufficient vadose zone of 30 m acting as natural filter that removes pollutants and other impurities from the water as it moves down to the ground water through natural filtration media consisting of pebbles, gravels, and coarse sand, charcoal and potassium permanganate layers. Quality improvement through proper infiltration management is expected to be achieved as given in Table-1(Bouwer, Herman, USA])

Table 1: Water quality Improvement

Parameter	Pollutant removal
Suspended Solids	Essentially complete removal
Dissolved Solids	No removal
Biodegradable organic compounds (BOD)	Essentially complete removal
Synthetic organic compounds	Some are almost completely removed, some significantly and some very little
Bacteria and viruses	Essentially complete removal due to zone of deariation. However, as precautionary measure, potassium permanganate layer has been also provided in the system.
Nitrogen	Significant removal
Phosphorus	Significant removal
Fluoride	Significant removal
Heavy metals	Significant to essential removal
Boron	No removal
Oil & grease & other hydrocarbons	79% to 98% removal. (For complete removal, charcoal layer has been provided as it acts as a good absorbent of oil & grease)

The above table clearly indicates that Rapid-infiltration soil-treatment systems are capable of removing essentially all biodegradable organics, suspended solids, and bacteria and viruses from the wastewater. They can also remove almost all the phosphorous and significantly reduce concentrations of nitrogen and heavy metals. Most of the quality improvement of the wastewater takes place in the top 1 m of the soil beneath the infiltration structures. Considerable additional movement in vadose zone and aquifer is needed for quality improvement in long term & to avoid concentration of pollutants in the upper top 10 m. However, to complete the renovation process (dieoff of bacteria and viruses, phosphate precipitation, decomposition of organics, taste and odor removal etc.), a rule of thumb is to allow at least 100 m distance of underground travel and an underground detention time of at least 1 month as studied by Asano, Takashi, USA.

5 Monitoring of Ground Water Regime

Monitoring well of suitable depth as per strata and water level may be installed for continuous record of water level and quality in the vicinity of such projects . Further rise in water level is envisaged during subsequent years.

6 Advantages

- No flooding of roads
- Increase in life of roads.
- Augmentation of ground water storage and control of decline of water levels.
- Improvement of quality of ground water.
- Reduction of soil erosion.

- Surviving water requirement during summer, drought etc. in cities and industrial areas.
- The method can also be applied on all highways for improving ground water regime and to increase life of roads.

7 Case Study

Road storm water recharge at Rotary Marg, Church road, Jaipur, Rajasthan State, India

Analysis of Recharge test in Rotary Bhawan reveals that instantaneous dissemination of water is 0.47 m^3 in 1 min = 0.5 m^3 per minute. Based on aquifer water intake capacity determined through recharge test and estimation of road runoff of 15 min. peak rainfall, percolation structures were designed with optimum numbers.

The area with soil / weathered rock has vertical permeability up to water level zone without impermeable layer. In this kind of situation, the percolation structures of average 2 m depth, 4 m length and 1.5 m width has been made along both sides of Rotary Marg from Rotary Bhawan to Sangam Tower. Such 14 structures on both the sides of the road have been made to recharge most of runoff generated in a single storm and are shown in Fig.-4. The percolation structures have natural filtration media of coarse sand, gravels and pebbles with charcoal layer of 0.1 m followed by 0.005 m layer of potassium permanganate and covered with removable slabs (Fig.–5). The road was requested to be made with 1 degree slope towards these structures from the center with the help of Jaipur Municipal Corporation.

The length of the road is about 400 m with average width of 8 m. Considering 600 mm annual rainfall and road catchment factor 0.75, direct runoff on road would be 1440 m^3/ annum. Rotary marg also receives runoff from the roofs of adjoining houses and Hathroi hillock. The additional catchment area works out to be nearly 4000 m^2. The additional runoff will be 1800 m^3/ annum.

The total runoff available for recharge will be around 3000 m^3 / annum. Considering 60 mm as peak rainfall for Jaipur region, single storm of 15 minutes is expected to generate runoff on road of the order of 80 m^3. Each structure will have 6 m^3 of water in the system at any point of time with recharge rate of 0.5 m^3 / min. 14 structures designed would be able to accommodate 80 m^3 of runoff during any single storm. Hence, systems designed would be functional efficiently in long term.

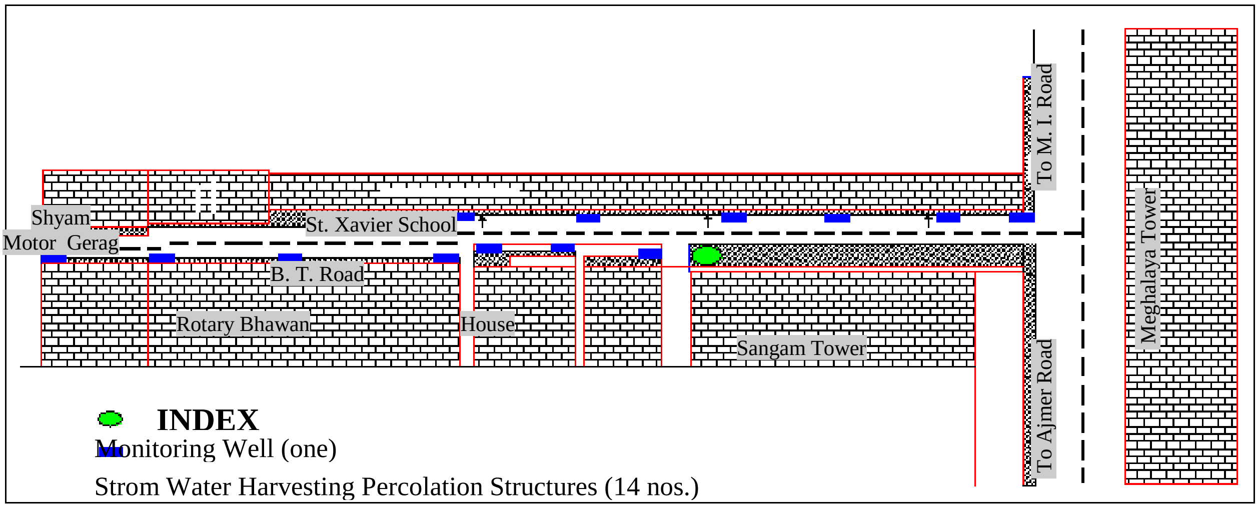

Fig.4

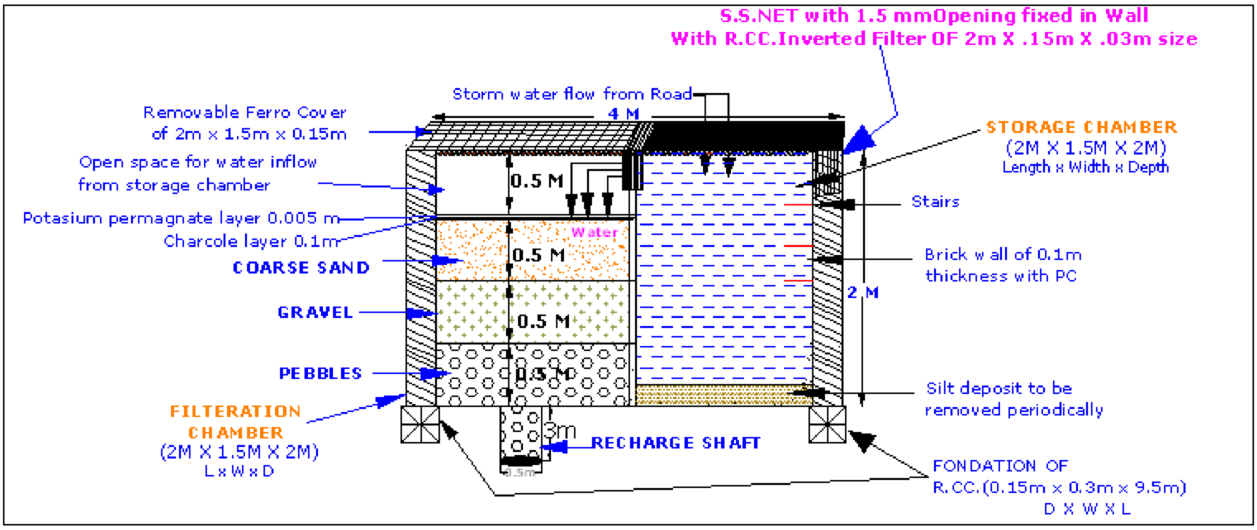

Fig.5

8 Conclusion

The techniques presented will be helpful in controlling storm water hazards in urban areas and industries with improvement in ground water storage by utilizing rainfall runoff on the roads. This method is less expensive then any other technique of artificial recharge, if implemented at the time of road construction itself. The innovatively designed structures are simple, easy to construct, operate and maintain. The implementation taken up in some industries for Hero Moto Corps at Dharuhera and Haridwar and Mayur Uniquoters at Jaipur has shown positive results of rise in water level or reducing decline in water level and improvement in water quality within short time. Further effects on ground water regime are under monitoring. Such projects are expected to solve storm drainage problem of cities and industries which would create hygienic conditions avoiding frequent maintenance and repairs of the roads. Besides, it may turn out to be lifeline in surviving additional water requirement of urban areas and industrial sectors.

9 Acknowledgement

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