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# Rain Water Harvesting - A Solution for Urban Heat Islands

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## Abstract

**In last 25 years, Metropolitan cities have doubled in population growth due to large rural migration. As the sizes of cities remain same, the areas which were not paved before 25 years are now paved using concrete & asphalt to fulfill the residential, commercial & industrial requirement of the growing population. This increases the temperature in the metropolitan region as compared to their surrounding areas, these phenomenon is termed as Urban Heat Island (UHI).**

**In these metropolitan cities, most of the rain water run-off goes wasted in the storm water drains instead of being harvested. We can use this rain water to retain the moisture in the earth which will help us to decrease the effect of Urban Heat Island.**

### Keywords

Urban heat island, metropolitan cities, moisture retention, rain water

## Introduction

An urban heat island is a metropolitan area that is consistently hotter than the surrounding area due to the modification of land surfaces, which use materials that effectively store short-wave radiation. Urban land surfaces such as concrete and asphalt act as a huge reservoir of heat, absorbing it in the day and releasing it at night. Never-ending urbanisation increases land surface temperatures and, over time, the city ends up as an island of heat. Delhi, Mumbai and their residents have been facing this ambush [of heat] for 20 years. It may eventually result in unprecedented repercussions such as heat waves, health impacts, human discomfort and increased mortality among the elderly.

The above phenomenon of urban heat islands can be taken care of with help of proper earth cooling techniques. Some of these techniques are cooling by underground earth tubes & by geothermal heat pump systems. There are four basic types of ground loop systems. Three of these -- horizontal, vertical, and pond/lake -- are closed-loop systems, while the fourth type of system is the open-loop system. The suitability of the best system depends on the climate, soil conditions, available land, and local installation costs at the site.

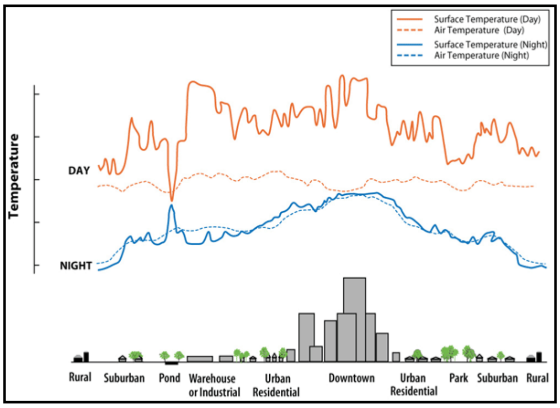


*Figure: 1, Temperature in cities*

According to the statement given by Centre for Science & Environment of Delhi, 65% of Rain water Run-off goes into the sea. Rain water if utilized & stored or recharged properly can benefit us in many ways. Normally the pH of rainwater varies between 6.3 and 7.9. The minimum and maximum mean temperature of rain water varies according to the place while for the study purpose we can take the minimum & maximum temperature variation to be between 10˚C - 30˚C.

Rain water can be used fruitfully by storing it in the confined acquifers during rainy season while extracting it during summer for the Earth cooling purpose with the help of moisture retention.

## Need for Study

Mumbai had the highest population density of 29,650 people per square km., while Kolkata had 23,900 people per square km. & Delhi had 11,050 people per square km. in January, 2007.

As seen in the figure around 70 % of the land in a metropolitan city is paved and non-permeable. There isn't any space left for heat to get absorbed in the earth, and hence these major cities end up being heat islands.

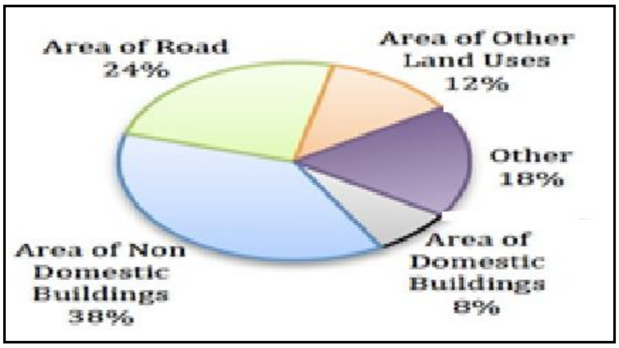


*Figure: 2, Use of land in cities*

Preliminary findings from the Delhi-based Energy and Resources Institute (Teri) show that temperatures in Delhi & Mumbai have risen 2˚C-3˚C in only 15 years. The ongoing study, based on NASA satellite readings, also shows the cities to be 5˚C-7˚C warmer than in the surrounding rural areas on summer nights.

It has been largely demonstrated that cities with variable landscapes and climates can exhibit temperatures several degrees higher than their rural surroundings (i.e. UHI effect), a phenomenon which if increases in the future, may result in a doubling of the urban to rural thermal ratio in the following decades. As it would be expected, the characteristic inclination towards warming of urban surfaces is exacerbated during hot days and heat waves, which reinforces the air temperature increase, particularly in ill-ventilated outdoor spaces or inner spaces of residential and commercial buildings with poor thermal isolation. This increases the overall energy consumption for cooling (i.e. refrigeration and air-conditioning), hence increasing the energy production by power plants, which leads to higher emissions of heat-trapping greenhouse gases such as carbon dioxide, as well as other pollutants such as sulphur dioxide, carbon monoxide and particulate matter. Furthermore, the increased energy demand means more costs to citizens and government, which in large metropolitan areas may induce significant economic impacts. On the other hand, UHIs promote high air temperatures that contribute to formation of ozone precursors, which combined photochemically produce ground level ozone.

A direct relationship has been found between UHI intensity peaks and heat-related illness and fatalities, due to the incidence of thermal discomfort on the human cardiovascular and respiratory systems. Heatstroke, heat exhaustion, heat syncope and heat cramps, are some of the main stress events, while a wide number of diseases may become worse, particularly in the elderly and children. In a similar way, respiratory and lung diseases have shown to be related to high ozone levels induced by heat events.

Present earth cooling systems & techniques are very costly. It is really expensive to tap these sources. Present systems require large man power as well very skilled labour to install the required system nearby to any residence. It can be fairly difficult and expensive to built the plants required to convert the hot water and steam into a usable electricity, while the efficiency of these kind of systems always are of great concern.

On comparing the precipitation patterns in the temperate regions of the world, precipitation in India is characterized by acute variation in both space and time. In our country 80 percent of the annual run off is limited to brief monsoon period generally less than 100 days. In total, country receives about 4000 BCM of water as precipitation annually out of which 700 BCM are lost in evaporation and another 700 BCM are lost during the flow on the ground. Also, the large part of the water namely 1500 BCM flows into the sea due to the floods, thus, the remaining available water is only 1100 BCM out of this ground water recharge accounts for 430 BCM per year and the present utilized surface water is 370 BCM, the balance unutilized water which can be harnessed is 300 BCM.

We do use large amount of water from the production tube well to cool the surrounding areas of small residential homes in order to decrease the effect of Urban Heat Islands during the peak summer days. This scenario can be seen mainly in the metropolitan cities

So, there is urgent need to use rain water as cost effective solution to decrease the Urban Heat Island effect.

### Objective of Study

Main objective is to somehow decrease the effect of UHI in the metropolitan cities by some sustainable solution. Rain water which goes wasted in the cities can be used to cool the earth is some way that will decrease the effect of UHI.

## Literature Survey

According to the news letter of Aquifer Thermal Energy Storage, Volume- I, Number-3 published in the year 1980, the Underground water storage was introduced in the Chinese cities. As a means of conserving energy, many Chinese factories and several other enterprises were making use of water -bearing formations to store cold or hot water for future use. In winter, cooled water was injected into an underground water-bearing formation to be recovered for air-conditioning or cooling purposes in summer. During the summer, water warmed by industrial surplus heat or solar energy was stored in the formation to be used in the winter for heating, humidity regulation, and bathing purposes.

In the summer of 1963, staff and workers of the geological administration, the water supply company, and several cotton mills of Shanghai made a united effort to control subsidence and replenish underground water resources by injecting treated industrial waste water or surface water into the ground. During this process it was found that the flow of water pumped into the water-bearing stratum was slow and the temperature of the water changed very little. It was then decided that water would be experimentally pumped underground in winter to be used in summer, and in 1965, 127 Shanghai factories carried out that experiment. The following summer 38 of the city's factories injected water underground to be used in winter. Both experiments proved successful.

Justine Anschütz describes about water harvesting & soil moisture retention in Agrodok 13. He illustrated the techniques of harvesting the surface run-off by infiltrating & storing the rain water in the (semi-)arid areas. The advantages of water harvesting and moisture retention techniques in (semi-)arid areas can be summarized as follows. A higher amount of water available for crops may lead to a greater reliability and a higher level of yields. In addition, it can tide a crop over an otherwise damaging dry spell and it can make crop production possible where none is viable under existing conditions. In many countries in the world small-scale, simple methods have been developed to collect surface runoff for productive purposes. Instead of runoff being left to cause erosion, it is harvested and utilized. A wide variety of water harvesting techniques with many different applications is available.

U.S Environmental Protection Agency stated in one of their article that in a hot, sunny summer day, roof and pavement surface temperatures can be 50–90°F (27–50°C) hotter than the air, while shaded or moist surfaces—often in more rural surroundings—remain close to air temperatures. These surface urban heat islands, particularly during the summer, have multiple impacts and contribute to atmospheric urban heat islands. Air temperatures in cities, particularly after sunset, can be as much as 22°F (12°C) warmer than the air in neighboring, less developed regions. Elevated temperatures from urban heat islands, particularly during the summer, can affect a community's environment and quality of life. While some impacts may be beneficial, such as lengthening the plant-growing season, the majority of them are negative. These impacts include Increased Energy Consumption, Elevated Emissions of Air Pollutants and Greenhouse Gases, Compromised Human Health and Comfort & Impaired Water Quality.

The Indian Institute of Human Settlements in the year 2011 stated in the Indian Urban Conference that in 1951, there were only 5 Indian cities with a population greater than 1 million and only 41 cities greater than 0.1 million population. Much of India effectively lived in 0.56 million villages, while in 2011, there were 3 cities with population greater than 10 million and 53 cities with population greater than 1 million. Over 833 million Indians lived in 0.64 million villages but 377 million lived in about 8000 urban centres and by 2031, it is projected that there will be 6 cities with a population greater than 10 million. This clearly indicated the growing problem of rural migration and increasing population in the metropolitan cities.

# Propound Designs

## Propound Design – 1

The surface run-off as well as roof top rain water enters into the gravity type filter chamber through inlet holes. The water gets filtered before percolating down the Earth. These recharge well acts as a bore well during the summer season to fetch the water for cooling of the earth. The moisture retention units can be installed up to certain deep in the soil depending upon the characteristics of the soil and its type. This is shown in the figure below.

The disadvantages of this design can be listed as follows:

1) The volume of the filter chamber would be very large if roof top and surface run-off are harvested, and accordingly the quantity of filter media will increase a lot.

2) There are chances of the filter chamber getting clogged and not working in the next monsoon. So it will need maintenance every year to keep it working continuously.

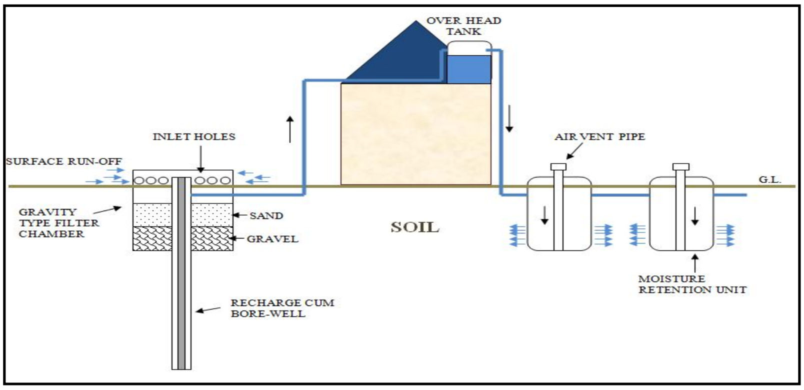


Figure. 3, Propound design – 1

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## Propound Design – 2

To overcome the disadvantages of the first design, two separate chambers are provided. The first chamber is the filtration chamber while the second chamber is the sedimentation chamber through which the water will enter into the recharge well. Water from the recharge well will get first stored into the storage tank, while when necessary in the summer days the moisture retention units will retain the suitable amount of moisture in the soil which will help in cooling of the Earth.

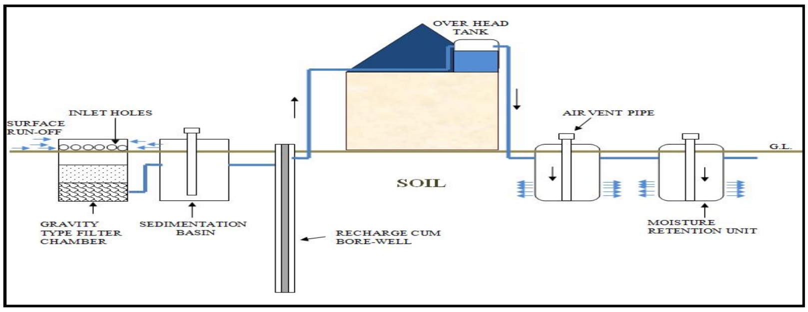


Figure: 4, Propound design – 2

## Propound Design – 3

The technique is similar to that of the propound design-2, but the vegetation can get benefit here if the moisture is retained up to the root zones of the plants. According to the depth of the roots of different plants we can provide the depth of moisture retention units accordingly. These will also help us to decrease the UHI effect in urban areas. This design can be used in the large farms and sloppy terrains to hold on the moisture, which is drained away in the form of surface run-off.

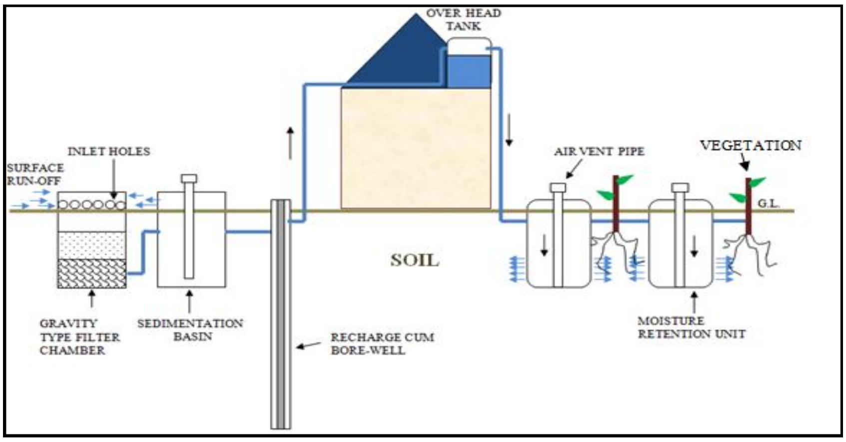


Figure: 5, Propound design – 3

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Figure: 6, Propound design – 3 for LDRP - ITR

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