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Design of Rainwater Harvesting Filter

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ABSTRACT: Rainfall is one of our primary sources of fresh water which is not used effectively. Water conservation, efficiency and reuse are becoming increasing important as we now face serious problems including reduced ground water and surface water levels, drought and changing climate patterns. Rainwater is considered to be the purest form of water, but it gets contaminated when it comes in contact with the catchment area. The present rain water harvesting filter available in the market only remove the larger particles like leaves and plastic waste but fails to remove fine silt and dust particles and animal waste which pollute the rainwater .These filters just contain a mesh with a pore size of 5mm to 10mm and are ineffective in reducing the turbidity , TDS and other parameters, not much importance is given to removal of bird/animal littering in catchment area. This work focuses on improving the usability of rainwater harvesting to use it for other potable water needs by incorporating a proper filtration system inside the harvesting system. The proposed filter consists activated carbon, geopolymer mesh, steel mesh to remove insoluble and soluble pollutants. By the actions of adsorption, absorption, pressure valves and various meshes the physical characteristics of the filtered water like its turbidity, colour, suspended solids and TDS are greatly improved thereby making it useful for some of the potable demand needs

Keywords: Rainwater harvesting, filters, activated carbon, turbidity, TDS, Suspended solids, self-cleansing mechanism

I. INTRODUCTION

The problem of shortage of water and its contamination is on the rise due to industrialization and urbanization. The protection of our primary source of water by harvesting and the development of cost effective remedial methods for its filtration is an essential need of the current environment [1]. Climate changes also adversely affect our hydrological cycle creating droughts and floods in corners of the world [2]. The world is facing a major global water crisis. A majority in developing countries like India do not have access to potable water sources. It also states that by 2025, half of the world's population will be living in water-stressed areas. Rainfall is our primary source of fresh water which is not used effectively [8]. The average rainfall in India is 300 - 650mm/year according to Open Govt data records. Due to uneven and very unreliable rain, the underground water table is low in some regions, also the water in bores is reducing at a great rate due to increased digging of bore wells In rural places the availability and accessibility of clean water is scarce, the only viable alternative is use of rainwater harvesting and its filtration [5].

In theory, Rainwater harvested is purer than surface water like rivers, but several studies indicate drinking untreated rain water to cause diseases like Salmonella and Campylobacter [9]. The rain water that is obtained gets contaminated by various types of bacteria that are present in the droppings of birds

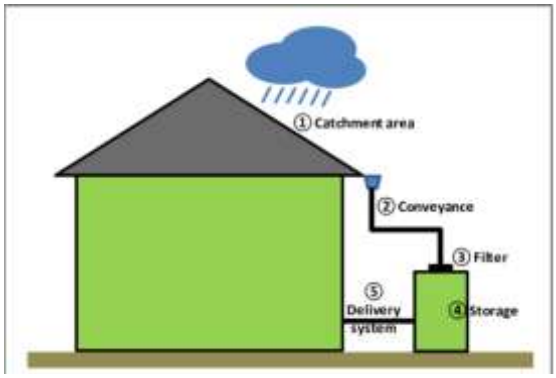

Fig 1 Rain water harvesting system

and other animals as it runs off the catchment area of the rooftop. Additionally, polluted air mixes

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unwanted substances in rain rendering it unusable without treatment [7]. Each parameter of water is to be noted and proper filtration techniques are to be suggested.

The present and conventional rain water filters available in the market only remove the floating debris in the collected water, thus it discourages users to use it even for non-potable use. Rainwater is found to have many impurities and also the presence of harmful microorganisms like e coli [5]. Therefore, it is obligatory to purify it and encourage its use for non-potable use. The main objective of preparing this report is to deliver a unified premise, for a feasible model of rainwater harvesting and filtering system which aids in harvesting and use of our primary source of water.
The rainwater is collected from the rooftop, due to anthropogenic activity, industrial emission and animal activity the collecting basin gets contaminated with pollutants, debris and microorganism. When the rain water flows over the rooftop it carries all the contaminates with it, the rain water goes through the gutter and then through the drainpipe which is connected to a filter set up at the ground floor. After flowing through the filter unit, water is collected for testing and compared to the BIS standards

II. ROOFTOP RAINWATER HARVESTING

Rooftop rainwater harvesting is one of the ancient techniques used for farming purposes in the middle east and India [8]. A basic roof rainwater harvesting system typically consists of a (1) roof catchment, (2) pipe system, (3) Screen filter, (4) storage and a delivery system.

The implementation of just a harvesting system without filtration mechanism and proper storage of Water, renders the collected water useless as many pollutants from air, rooftop material, and other anthropogenic activities from humans and animal waste needs to be filtered out.

Primary catchment area rooftop contains a mixture of chemical and biological particles, these may include nutrients, heavy metals and organic compounds such as petroleum hydrocarbons [11].

The biological compounds may include bacteria and other pathogens. Rainfall water provides the cleanest naturally occurring water which can be used, but this is just in theory [4]. The general notion is that roof harvested rainwater is safe to drink and this is supported by limited epidemiological evidence.

Good quality water is one which does not cause any diseases, does not contain any harmful or radioactive materials. It should be astatically appealing and free from questionable taste and colour free.

Dust on rooftops in industrial cities make water mix with certain heavy metals. Heavy metals combine with body bio-molecules like proteins and enzymes mutilating their structure and hindering their biological functions

Turbidity is the cloudiness of the liquid with huge quantities of small individual particles with size ranging from nanometre to micrometre which makes the light to scatter rather than to transmit in a straight line through the medium [10]. The medium concerned is ordinarily a liquid in which light is dissipated by colloidal or organic, or inorganic matter, or fine insoluble particles.

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The measurement of hydrogen ion concentration is called pH. Which tells about the acidity and alkalinity of a sample. we can infer that the rain water is alkaline which is due to soil dust which contains calcium ions. It is not acidic as the sample site is not in proximity to any industrial site or exposed to heavy vehicular movement. The sample was collected in a region where the road side dust is abundant in the atmosphere.

The total measurement of undissolved solids in the sample like silt, dust and other particles with more than 2 microns are called total suspended solids

The results show TSS is negligible in rainwater whereas in runoff rainwater is more than permissible limit it is due to silt and dust deposition due to vehicular and construction activity. Due to wind, silt and dust gets deposit on rooftop.

III. MATERIALS

The materials used in the filter unit are placed in decreasing order of pore size. This is done to prevent larger particles entering the finer pore sized media, which may lead to blocking/Clogging of the media. This increases the efficiency of filtration and prolongs the life of the filter media.

a. Filter floss

The floss is the 1st set of filter media that comes in contact with the rainwater coming from the over flow unit. The filter floss consists of two layers namely, fine and coarse filter floss. The

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coarse filter floss has a larger pore size about 1mm to 0.2mm and obstructs the particles equal this or larger.

The fine filter floss has a much more smaller pore size ranging 800-400 micron. The main purpose of the floss is to perform mechanical filtration, and hence removing respective size particles from the contaminated rainwater.

b. Granular activated carbon

The major advantage of granular activated carbon is that it provides a dual property to perform chemical filtration and also mechanical filtration. The process of mechanical filtration is done by the carbon particles which form voids in between each other when placed closely. The main feature of granular activated carbon is to perform chemical filtration, this is achieved by the property of activated carbon to possess a high surface area. The availability of such a high surface area leads to the possibility of adsorption of chemicals like chlorine and any other chemical to get adsorbed on to the particles of granular activated carbon.

c. Filter bags

These are very similar to having the properties of filter floss to perform mechanical filtration, but these have a even smaller pore size. The ones used in this layout are 200micron and 5 micron. They completed the final stage in filter unit to polish the rainwater by removing the finest particles present [3] [6].

IV. METHODOLOGY

The design of the initial filter is such that it uses a down flow process of filtration where the water moves along the gravitational force. This enables movement of water with any aid of electronic equipment. As the water arrives from the rooftop into the filtration overflow (fig.3) unit the nylon mesh will obstruct the larger materials and this will prevent the blocking of the filter media entrance in the long term and will allow free water movement intron the filter media, now as the water moves into the filtration unit (fig 4) and the filter media remove contaminants like dust, silt, minute particles picked up by the water when in contact with the rooftop.

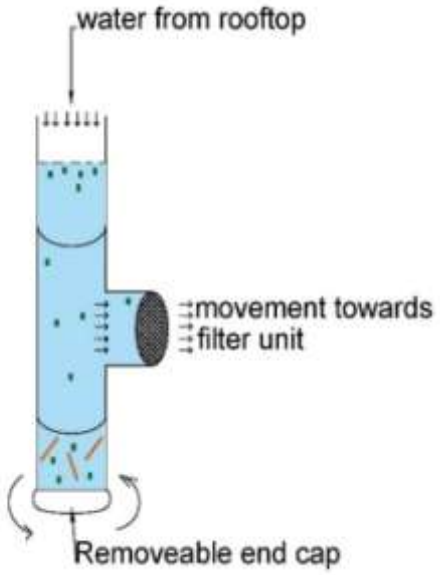

Fig.3 over flow layout

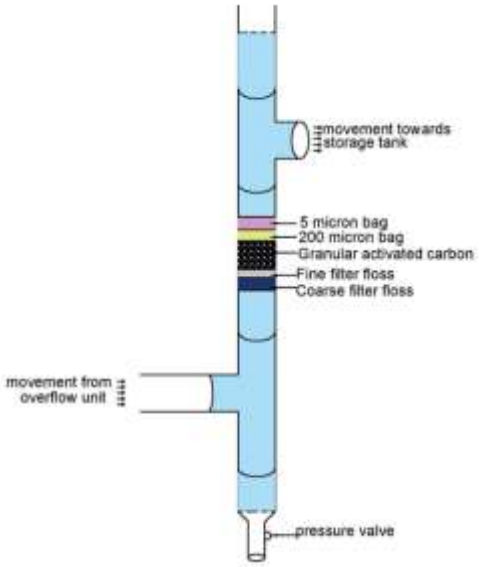

Fig.4 filtration layout

This process ensures water entering the storage tank or recharge pit is free of contaminants, but over time the filter media get filled with these contaminants, which results in reduction of filter efficiency and also clogging of the filter unit. To rectify the problem the filter media unit must be removed, cleaned or replaced depending on the situation. This is a very tedious process, hence to avoid this the concept of self-cleaning mechanism of filter is adopted.

The concept of self-cleaning is a very simple method which uses a pressure valve. Th valve uses general principle of pressure, where a

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buildup in pressure on one end results activation of the valve which changes the direction of flow resulting in a hydraulic jerk in the filter media. Which later results in a backwash.

In order to achieve self-cleaning, there is need of specific components in the filtration system. To begin with the conventional downflow system of filtration will be replaced by an up flow method of filtration. The process of up flow filtration is very crucial as the water moves against the gravitational force yet achieves to move upwards due the flow pressure of the rainwater entering from the rooftop into the filtration unit, an added advantage to u flow filtration is that suspended particles will find it a bit more difficult to move against the gravitational force and will tend to settle below the filter media resulting in lesser contaminants passing into the filter media. Once the water passes through the filter media and the contaminants get removed in a typical manner of mechanical and chemical filtration, the water will pass into a storage tank which once filled will automatically close the entrance from the filtration unit with the help of a float valve. Due to the tank entrance getting blocked there will be an accumulation of water in the filtration unit above the filter media. The pressure gradually rises as there is an increase in the volume of water. This creation of added pressure is very essential for the activation of the pressure valve, once the pressure threshold of the valve is reached it opens up. This creates and path where the water can now start to exit from, but now the direction of flow changes from up flow to down flow. This change in direction results in a hydraulic jerk to take place in the filter media, which means a backwash stage is achieved. The resultant of backwash leads to removal of contaminants that were obstructed by

the media during up flow filtration, out of the filtration unit. As long as the storage tank entrance is closed the filtration unit will tend to carry out a series' of backwashes. Which will involve closing of the pressure valve when the pressure reaches zero, and opening of the valve when the threshold pressure is reached. Due to these multiple backwashes the media will be free of contaminants, which results in no provision of clogging and reduction in filtration efficiency of the media. The backwashing will stop as soon as the tank entrance is open and the filter will resume up flow filtration, this is well known as a rest stage.

V. RESULT

The result of this mechanism is that the is no need for human intervention to clean and replace the media multiple times.

The filter is designed mainly to overcome the drawbacks of the conventional filter which is presently available in the market. The main advantage of this system being the robustness of this design which cleanses the rainwater and makes it usable immediately after rainwater is filtered through it and the use of pressure valve in it also solves the problem of dissembling the system frequently, which is carried out by backwashing. The testing of the new design prototype fitted with the pressure valve is to be carried out in order to examine the proper functioning of the system.

Sl.no	Test	Results (1)	Results (2)	Results (3)	Protocol
1.	Turbidity, NTU	41.9	41.9	26.4	IS 3025 (part-10): 1984 Reaff.2017
2.	pH value	8.1	8.1	7.8	IS 3025 (part-11): 1983 Reaff.2017
3.	Total dissolved solids, mg/L	546.0	546.0	356.0	IS 3025 (part-16): 1984 Reaff.2017
4.	Total Suspended solids mg/L	679.0	679.0	189.0	IS: 3025 (Part 17): 1984 Reaff.2017

Table 1

For conducting this research three sample where collected and the sample are sample one is rainwater collected after flowing over the catchment, sample two is rainwater form conventional RWH and sample three is from proposed rainwater filter. The parameters of sample one is turbidity 41.9 NTU, pH
of 8.1, Total dissolved solids of 546 mg/L and Total Suspended solids of 679 mg/L. The sample 2 and 1 hade same results. Sample three had turbidity of 26.6 NTU, pH of 7.8, Total dissolved solids of 546 mg/L and Total Suspended solids of 189 mg/L.

VI. CONCLUSION AND FUTURE SCOPE

Water that is clean and fresh is a limited source. With all the climate changes, droughts happening around us, Fresh water is becoming one

of our most precious resources. While water covers 70% of the earth many parts of our world suffer from clean water shortage. Water is important for sustaining life so Conserving and preserving fresh waters is necessary. One of the effective sources of fresh water supply is Rainwater, thousands of litres is wasted in run off. Rainwater harvesting is a best way to conserve rainwater. This collected water can be stored for later use and recharged into the groundwater again. Rainwater is the primary source of water and recognising its value is of at most importance.As we know by now rain water collected in its primary form is contaminated chemically, biologically and physically, thus this makes the use of rain water limited. Present water filters available in the market only remove the floating debris and to prevent overflow. This has no effect on the soluble particles present in the contaminated water, thus the need to design an appropriate filter to remove these contaminants is needed.

The Proposed filter containing filter floss, activated carbon and the multiple layers of mesh helps in removing the dissolved materials there by reducing about 38% of turbidity, 72% of TSS, 32% of TDS when compared to runoff rainwater results. The obtained results from proposed filter are not in drinking standards. By using more advanced filtering prosses and materials, the use of rainwater can be extended to other potable water needs extending its usability. An auto cleaning design is proposed which helps reduce the maintenance of the filter media and increases its longevity. Thus, a Rainwater water harvesting filter is proposed to remove not completely but some percentage of insoluble water contaminants from rooftops and other sources to make the water more usable

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