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QUALITY ANALYSIS OF ROOF-TOP RAINWATER HARVESTED IN DIFFERENT MATERIALS AT HIGH TEMPERATURE

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ABSTRACT

Rainwater trait is a critical factor deciding about its appropriateness for using it as a source of drinking water. But the hasty increase in industrialization and urbanization has badly decreased the rainwater quality these days. This present study has been carried out with a view to analyze the quality and suitability of roof-top harvested rainwater for drinking purpose. To carry out this experimentation work the rainwater was collected from the various selected roof-tops and was tested for certain duration to study various parameters regarding its quality with reference to the Indian Standards on storage with respect to time. The objective is to know variations in the different chemical parameters of the stored water with time which may occur during its storage and it is necessary to figure out before using as drinking water. The rainwater was assorted from two different locations within the study area, based on surroundings of roof material, on the material of downpipe and different pollution level based on traffic load in the vicinity. The experiments carried out in the present study provide a precise methodology for storing the harvested rainwater with respect to different material and temperature with time.

INTRODUCTION

Rainwater is usually considered as an intact and mostly treated as a safe and a sheer source of potable water being used commonly in most of the rural and urban areas in almost all the developing countries of the world. Due to lack of sufficient sources of fresh drinking water it is the normal habit of people to collect and store rainwater to use during dry periods of the year in many parts of India. The eagerness to have an idea about the quality of this stored rainwater has proposed the following study. The growing urbanization has suppressed the fresh water sources. The consciousness for the use of safe water has also caused an increase in more demand of fresh water among the people *(1), (2).* It has been predicted that worldwide about 1200 million people have their health at risk which may lead to the demise of about 15 million children annually. Rain is the initial state of water in the hydrological cycle where-as lakes, rivers and groundwater are secondary sources of water, but disastrously with time it has been ignored badly that the rain is the main source contributing to all other alternate sources of water. The method of rainwater harvesting involves construction of water retaining structures so as to value the rain and to use it at the place of its occurrence.

Rainwater harvesting has now become a necessity to manage with the acute shortage of water in most of the parts in the country. The prime way of rainwater harvesting is roof-top rainwater harvesting as roofs are found to be less prone to any type of contamination. But in case of a dry period or if roofs are full of dirt or any other kind of undesirable materials then the rainwater may get polluted *(3*). Roof-top rainwater harvesting is emanating at a rapid rate since last few decades owing to severe crisis of drinking water due to various climatic changes and looming development in many countries. The present study mainly emphasizes on the quality of roof-top harvested rainwater and the various factors affecting the quality. The quality of the roof-top harvested water is usually found to be contrasting from the drinking water standards despite of the fact that the rainwater is considered to be the purest form of water. Heavy metals and traces of pollutants are also found to be present sometimes owing to different roof materials and site conditions *(4).* The water quality of harvested water after precipitation depends upon construction and design of the catchment, cleaning and maintenance of the whole system and the final treatment of water before its use (*5*). The prime importance in the current study is organized upon the fact that the suitability of roof-top harvested rainwater depends more on the way of its collection and storage, storage materials

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and also the microbiological quality and first flush systems should be given importance before considering it for potable use (*6*), *(7*). Also it becomes necessary to analyze the changes occurring in the quality of water during its storage with respect to time.

STUDY AREA

The area for the present study is esteemed Indian Institute of Technology placed in Roorkee city of Uttarakhand state, India. The Institute comes among the finest technological institutions in the world and has a great role in technological development of all sectors. Roorkee city is situated in Haridwar district of Uttarakhand expanding over a flat land and having an immense view of Himalayan ranges covering it in both North-east and the East. The city is on the banks of the Ganges canal situated on the National highway 58 on the way between Dehradun and Delhi. The most influential trait of the city is the Upper Ganges Canal flowing from north to south segregating the city. It is also known for Roorkee Cantonment which is oldest in the country and has the headquarters of Bengal sappers since 1853. The renowned IIT Roorkee is located in the city. The Roorkee city is located at 29.87˚N 77.88˚E having an average elevation of 268 meters (879 feet) and is present at 172 kilometers from the north of the Indian capital, New Delhi between Yamuna and Ganges rivers and near to the Himalayan foothills.

SAMPLING STATIONS AND SAMPLE COLLECTION

The selection of the locations for the sample collection was done based on their surroundings, their proximity to the high traffic load areas, and different intensities of pollution. Based on this norm two locations were preferred within the campus Sarojini Bhawan, a girls hostel present in the interior of the campus, whose major part is covered by trees and away from any kind of vehicular pollution and another location chosen was Ghananand Pandey hostel, which is on the outskirts of the campus and is quite near to the roads having heavy traffic load and has more pollution content in the surroundings. The rainwater from roof-tops was collected in a single event of rainfall through containers placed under downpipes in another polyethylene container initially due to the difficulty in direct collection of rainwater *(8).*

METHODOLOGY AND DATA PRESENTATION

The rainwater collected from the roof-tops was stored in partial sunlight in two different materials polyethylene and borosilicate glass. The experiments were carried out at a time interval of one month from September to February to determine its quality in accordance with the drinking water specifications as given in IS 10500: 2012 for analyzing parameters like turbidity, acidity, pH, hardness, alkalinity, chloride, dissolved oxygen, specific conductivity and total dissolved solids. It was the main priority to collect rainwater in the single event of rainfall itself while harvesting the rainwater. The specific conductivity and pH were measured using digital testers. The first testing was carried at about one hour after storage of rainwater at about 11 AM and all the readings at every interval were taken at the same time only.

Table 1a Range of parameters in different materials at high temperature

High temperature data G.P Hostel										
Parameters	**25/9/2015**		**1/11/2015**		**1/12/2015**		**2/1/2016**		**5/2/2016**	
	Plastic	**Glass**	**Plastic**	**Glass**	**Plastic**	**Glass**	**Plastic**	**Glass**	**Plastic**	**Glass**
Turbidity	1	1	0	0	0	0	0	0	0	0
Acidity	10	10	10	10	10	10	10	10	10	10
Ph	6.5	6.5	5.5	7.5	5.5	7	7	7	7	9
Hardness	30	30	28	36	32	38	24	40	22	50
Alkalinity	50	50	20	30	20	30	40	30	30	40
Chloride	30	30	10	10	10	10	10	10	10	10
Dissolved oxygen	7.15	7.15	6.5	1.95	1.3	7.8	1.95	7.15	7.8	9.1
Specific conductivity	5	5	6	12	6	11	6	13	7	23
TDS	32.5	32.5	39	78	39	71.5	39	84.5	45.5	149.5
Microbiological Quality	P	P	P	P	P	P	N	N	N	N

Table 1b Range of parameters in different materials at high temperature

High temperature Sarojini Bhawan										
Parameters	**25/9/2015**		**1/11/2015**		**1/12/2015**		**2/1/2016**		**5/2/2016**	
	Plastic	**Glass**	**Plastic**	**Glass**	**Plastic**	**Glass**	**Plastic**	**Glass**	**Plastic**	**Glass**
Turbidity	5	5	0	0	0	0	0	0	0	0
Acidity	10	10	10	10	10	10	10	10	10	10
Ph	6	6	5.5	5.5	5.5	5.5	5.5	5.5	9	9
Hardness	40	40	40	75	50	50	50	75	50	50
Alkalinity	40	40	200	200	200	200	200	200	40	40
Chloride	20	20	20	20	20	10	10	10	10	10
Dissolved oxygen	5.2	5.2	6.5	1.95	5.85	7.8	3.9	1.30	8.45	6.5
Specific conductivity	5	5	7	4	4	4	3	3	4	5
TDS	32.5	32.5	45.5	26	26	26	19.5	19.5	26	32.5
Microbiological Quality	P	P	P	P	P	P	N	N	N	N

The different parameters for the water quality analysis were evaluated by using Pack test containing simplified chemical analysis products for water. Total dissolved solids were determined by taking the product of specific conductivity value with the constant 0.65. Bacteria and Coliform were even tested at an interval of four weeks. The main consideration during experimentation was that there should not be any addition of water in the stored water during entire storage stage (*9*). Also to

avoid algae growth the storage containers should be protected from direct sunlight (*10*). The different values of parameters while experimentation has been shown in Table 1 (a & b).

RESULTS AND DISCUSSIONS

There is initial turbidity in the sample in all conditions which is due to the left out amount of debris in the harvested water which was not flushed away in the first rainfall and got settled during storage causing variation in turbidity in later stages of storage which is in accordance with the Drinking Water Specifications and WHO guidelines (11, 12).

Acidity is found to be constant throughout the storage and is directly proportional to pH which is also within the acceptable limits, from the current experimentation it can also be concluded that quality of water with respect to pH is found to be better in polyethylene container compared to borosilicate one. Hardness as such has no adverse effect on health and is found to be varying between 20mg/l to 75mg/l which is under acceptable limit as per the guidelines. Alkalinity is varying between 20mg/l to 200mg/l during entire experimentation and up to 400mg/l it is suitable for potable use. Chloride is also under the specified limit. Dissolved oxygen is found to be varying in all the conditions proving that dissolved oxygen varies with temperature and thus shows variation at all the stages of storage and experimentation. In the current study from the health point of view dissolved oxygen only imparts taste to water; it has no adverse effect on human health.

Total dissolved solids are directly proportional to the specific conductivity of water and up to 500mg/l it is good for potable use. The result analysis of the experiments indicates that all the values of specific conductivity and total dissolved solids in this current study are found to be within the acceptable limits of the standards and guidelines. Microbiological quality also improves with time if there is no addition of water during entire storage; initially the test results came positive indicating unsuitability of harvested water for potable use but with time the quality has improved and test results came negative.

CONCLUSION

Water for drinking should be essentially free from minerals, organic substances and other organisms which can cause contrary physiological effects if consumed regularly for a long duration of time. In the present study it can be concluded that the water quality improves with time if water is not added to the stored water and proper care is taken while its collection and storage.

Also as per the results obtained it is found that a polyethylene container is far better compared to a borosilicate container with respect to both microbiological and drinking water parameters if the quality of the stored roof-top harvested water is to be maintained for a longer duration.

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