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COMPARITIVE STUDY ON PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF HARVESTED RAINWATER AND NON HARVESTED GROUNDWATER

Suparna Deshmukh
Department of Chemistry, S. K. Gandhi College, Kada- 414202, Dist. Beed,
State Maharashtra
*E-mail: suparna.deshmukh@gmail.com

ABSTRACT

Rain Water Harvesting, an effective remedy on the water crisis, is a method of capturing the rainwater from rooftop catchment and its storage in subsurface groundwater reservoirs. It is a multipurpose way of supplying water in which rainwater from rooftops can be used for domestic purposes by storing.In many states where it has made mandatory, the implementation has become successful in water conservation and watershed management. Kada, a village in district Beed of Maharashtra State in India, is in a strongly drought-prone area. It is in this region present studies were undertaken for the conservation of natural rainwater and its storage in either surface water or in tube-wells. By constructing Rain Water Harvesting systems at five different locations in Kada, which included schools and some crowded public places,the researcher has found a successful rise in water levels of bore-wells and people are enjoying the results. Studies were also carried out to find the water quality and purity of harvested rainwater and it was compared with the water quality of non-harvested groundwater in the same vicinity. Water samples from six different sites were assessed for physicochemical analysis and from ten sites for bacteriological analysis. The different physicochemical parameters studied are pH, turbidity, chlorides, nitrates, sulfates, TDS, hardness, alkalinity, iron and fluoride. Researcher assessed potability as per IS 10500 Standards for drinking water quality assessment , and comparative studies showed that water gets more purified naturally when rainwater is harvested.

Keywords: Water crisis**,** Rainwater harvesting, Physic-chemical analysis, Bacteriological analysis.

INTRODUCTION

Rain Water Harvesting is the most sustainable solution on water crisis[1]. It is the most convenient and easily adaptable method for overcoming water scarcity during the water crisis. Rainwater harvesting is a technique of collection of rainwater from rooftop catchment and its storage in sub-surface natural reservoirs or tanks before it is lost as surface runoff. One of the most efficient methods of rainwater harvesting is Roof Top Water HarvestingEfforts should be made to ensure that common man gets sufficient pure water, pure air, and pure food. Implementing this fact, it has been decided to procure Rain Water Harvesting system at some public places in Kada town, in district Beed of Maharashtra state in India as Kada is the village where total annual rainfall is very less**.** Most prominent advantages of RWH includes:

(a) It can minimize the load and pressure on public water supply which is the main source of water supplies in cities;

(b) It is cost-effective and efficient method and hence is economically feasible and affordable to common man;

(c) It increases moisture holding capacity of soil important for development of vegetation

(d) Groundwater level gets increased and highly recharged during rainfall as studied by[1]. RWH can also overcome the problem of the water crisis, it can reduce the load on traditional water sources, and can also alleviate nonpoint source pollutant loads, it can help in controlling climate change impacts, and can contribute to the stormwater management as discussed by E. Eroksuz and A. Rahman, etal[2-6].The main cause behind the problem of the water crisis is that the consumption and requirement of fresh water have

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increased up to a huge demand in past 100 years, and is estimated to be increased by more than 500%, resulting in freshwater scarcity. It is estimated that by 2025 two-thirds of the total population in India, will live in water-stressed areas**.** Seven billion people on the earth today are dependent on groundwater for irrigation, industrial, environmental and domestic applications[6]. As harvested rainwater can be used for drinking purposes; it is important to assess its quality[7]. It is equally important to monitor the quality of harvested rainwater , for potential health risk because of the presence of chemical and microbiological contaminants. Factors like local climate, atmospheric pollution, hygienic conditions contribute to the quality of water collected from the rooftop.[8] It has been found out that the collected water by RWH technique, does not always meet the standard limits due to improper collection.[9-11] By giving proper treatment if required, it can be easily made as potable water. It is in this concern; water quality of harvested rainwater has been assessed and is compared with quality assessed for non- harvested water.

Rationale Behind Choosing the Problem

Kada is a village in AshtiTahsil of Beed district of Maharashtra State, in IndiaThis region is known to be the adversely drought-prone area. The total population of the village is about 15,000, and there are near about 3000 houses. It belongs to Marathwada Region and also Aurangabad division. It is located 6 Km from AshtiTahsil, 100 Km from District Beed,as well as 274 Km from State capital, Mumbai. It is 552 meters above sea level.There is an Igneous type of rock, all over in the town, which is a Primary rock, and thus water does not get percolated properly. Total rainfall per annum in the village and vicinity is very less about 500-600 mm only. The main source of water supply in the village is Bore-well or Tube-well which are about 400 to 700 feet deep. More than 80% of the Bore-wells gets dried out completely during the months of November or December. Villagers have to pay Rs.5 to Rs. 7 per five liters of water during the period of January to June. At most of the places, water tankers supply this water. The severity of the problem of water scarcity in village KADA, situated in District Beed of Maharashtra State, could be reduced by rainwater harvesting to improve water supply, food production and ultimately provide food security. Households with severe water scarcity mostly in drought-prone areas will be benefited from Rain Water Harvesting system. Since rainwater harvesting leads to a smooth water supply which can be utilized for multi-folded purposes, it can equally contribute to income generation. If 80% of total rainwater can be collected then 40,000 liters of rainwater will be available for storage. Depending on the amount of the rainwater collecting tank, and the distribution of rainfall, it is easy to collect 40,000 liters of rain water[8].The available rooftop is used to collect rainwater.

It is a general observation that a large number of schools do not have a reliable source of water for drinking as well as for other uses. The school rooftop rainwater harvesting system can provide a source of water which can be utilized for many purposes such as domestic uses, hygienic uses, and drinking purposes too, after purification. On the basis of advantages of Roof-top Rain Water Harvesting System,the researcher has constructed Rain Water Harvesting System on buildings of all schools, at some public places like Police Station in the town and also on a bank situated in the village Kada. The main purpose behind selection is that all these areas are always crowded and are facing water scarcity badly. Bacteriological and physicochemical analysis have been carried out to prove the utility of harvested rainwater for drinking purposes.Thus the objectives of the present studies are as follows.

Objective of the Study

The objectives of the present study are as under:

1. Rainwater harvesting (RWH) system is to be constructed on crowded public places suffering badly from the water crisis.
2. To study the efficiency of Rainwater harvesting system and to educate and make people aware of the problem of the water crisis.
3. To carry out a comparative study on Bacteriological status, and on physicochemical parameters of harvested rainwater and non-harvested water to assess the purity of harvested rainwater.

EXPERIMENTAL

The Water Samples were collected from six different places in the morning hours between 9 to 11am, in Polythene Bottles during the beginning of summer that is in the month of March. For bacteriological analysis sterilized glass bottles were used. The water samples were immediately brought into the laboratory for the estimation of various physicochemical parameters like water temperature, pH was recorded by using Thermometer and Digital pH Meter. (Systronics). Turbidity by Nephelometer of SYSTRONICS, respectively. The spectrophotometer of Systronics make, is used as per requirement. All the reagents including SPADNS were of Anal Grade with maximum purity. Methods of analysis were according to manual on water and wastewater analysis by NEERI, Nagpur and are based on IS 10500 standards.

Methodology

Rooftop rainwater harvesting is the process of collecting rainwater from rooftops into an underground tank or sump for productive use[17].Thus in brief, the methods of rainwater harvesting consist of two types:

1. A method in which rainwater is stored in the above ground or underground sumps or overhead tanks and is used directly for all sorts of domestic purposes.[11]
2. A method in which rainwater is recharged to ground through recharge pits, dug wells, bore-wells,etc.

In the present study, the researcher used the method of groundwater recharge in which 5x5ft. the pit was dug, plastered with concrete and pipeline connecting all the roof out-holes was introduced in it. Water storing in this pit was directed to enter into bore-wells through drilled holes and through the percolations. The tank was sealed from the top either with Cudappah slabs or Concrete slabs or any local stone. Since rainwater is pure as it falls from the sky, it is necessary that the roof is kept clean to retain the purity of rainwater when it is collected. The roof was kept clean by sweeping and cleaning daily during the rainy season in the district**.** The gutters of PVC collected the rainwater from the rooftop and transferred it to a filter**[2]**. On sloping roofs, PVC gutters can pick up leaves, dust, small twigs, and other organic matter. The gutters should be inspected and cleaned daily. The entry point of water from the roof to gutter was provided with a filter or the pit was filled with gravel so that water entered gets naturally filtered. The filter is very important in keeping rainwater clean before entering to storage tanks. The researcher selected five public sites which included schools, college, bank and police station situated in Kada town. For understanding the biological purity, after six months, the researcher collected the samples from five sites where rainwater was harvested and also from non- harvested sites in the vicinity. The researcher also interviewed the concerned authorities at each site of study to understand how much water level has been increased. After six months comparative study on bacteriological analysis was carried out to assess the potable quality of harvested and non-harvested rainwater at 10 sites.

Water Sample Collection Sites

1. Bhagini Nivedita Kanya Vidyalaya, Source : Bore-well
2. Z. P. School, Source Bore-well
3. Residence of Mrs. Anita Takale Source :Main Stream of Water supply, Tap Water
4. Residence Besides Z.P. School: Source : Tap water
5. Gram-Panchayat Office Main Stream
6. S. B. I, Kada, Source : Bore-well
7. The restaurant at S.T. Stand Source : Tanker water which is supplied throughout town
8. Motilal Kothari Vidyalaya, Source : Drinking Water Tank
9. Police Station ; Source : Bore-well

10. R. D. College Of Pharmacy : Source : Bore-well. Out of these ten sites, RWH was done only at above stated 5 sites, while other sites are their neighboring sites, where RWH was not done.

RESULTS AND DISCUSSION

After completion of the work, the researcher conducted the interviews of the beneficiaries to ascertain the benefits of RWH, or to get feedback on the project. The beneficiaries informed that they are enjoying an increase in water levels of bore-wells. At each of these sites, 5 people were interviewed and questions were asked regarding the increase in the levels of water of bore-well where RWH was done. The sites where RWH was not done are still facing the problem of water scarcity. Z. P. School authorities, who are now enjoying the results of RWH, told that until now they were facing a lot of shortage of water and the only source was tanker water which was supplied on either alternate days or twice a week. Since RWH has been implemented, there has been absolutely no need to use tanker water. Authorities at B.N. Vidyalaya, a school, said that; they are enjoying ample water, even in the month of March, as otherwise, their water in the bore-well dries by the month of November itself. People at Police Station said that before RWH, they did not have water for their regular use like for using toilets, washing purposes etc. but after applying RWH not only the daily requirements of water are fulfilled , but also, water can be used for gardening purposes etc.

Fig.-2: Underground Collection Tank for collecting Rain Water at one of Site: R.D Pharmacy College, Kada

The method adopted in present studies same as shown in the above figure. All the methods used for bacteriological analysis of harvested rainwater and non-harvested one , are according to Water Quality Monitoring –Edited by J. Bartram and R. Balance.[9]A Practical Guide to the design and implementation of Fresh Water Quality Studies And Monitoring Programmes, Published on behalf of United Nations Environment Programme and the World Health Organization@ 1996 UNEP/WHO. The discharge of wastes from municipal sewers which contains human feces forms an important source of bacteriological pollution of water.Water contaminated with such effluents may contain pathogenic microorganisms which cause a health hazard to human. Such fecal contamination of water is determined by carrying out microbiological analysis. The contamination is supposed to be severe when the indicator organisms are present in large numbers. Such bacteria are present in clumps in large numbers and are not present as individual bacteria. Hence the number of clumps of bacteria are to be counted while enumerating bacteria.

Total coliforms refers to a large group of Gram-negative, rod-shaped bacteria similar in characteristics. The group includes Thermotolerant coliforms and bacteria of fecal origin, as well as some bacteria that may be isolated from environmental sources. Hence only the presence of coliforms may or may not indicate fecal contamination. Total coliforms including E. Coli,or Escherichia Coli is the small class of gram-negative. Enterobacteriaceae which ferment lactose to produce gas and acid when incubated at 35^0C for 24-48 hours. Fecal Coli-form is the heat inhibited or thermotolerant form of E. Coli bacteria that continue to ferment some lactose to produce some gas and acid when incubated at 44.5^0C for only 24 hours. Thus more than 95% of thermotolerant coliforms isolated from water are the gut organisms. According to WHO, it is observed that the mortality rate of water associated diseases exceeds 5 million per year. The major source of fecal microorganisms is the discharge of wastewaters in freshwater resources.

Fig.-3: Roof Top Rain Water Harvesting Source: Images on Internet

Inadequate and accessible water resources must be available to all as water is an essential entity for life. For achieving safe drinking water quality, all efforts should be taken and to improve water quality, rainwater harvesting could be a possible way. In the present research, an effort has been made to carry out a comparative study on Bacteriological analysis of harvested rainwater and a non-harvested one. To detect the presence of coliforms in water, two techniques are commonly used. In these studies, "Multiple Fermentation Tubes, also called as MPN," technique is used as it can be easily applicable to all types of waters.[7]In this method aliquots of water sample are introduced in the test- tubes containing a culture medium. These tubes are then incubated for at 27^0C for 48 hours.[18]Fecal coliform bacteria, or thermo-tolerant bacteria are studied, for their presence, in the laboratory by their ability to ferment lactose, with the production of acid and gas at 44.5^0C, for 24hours by using Brilliant Green Lactose bile broth media. Confirmatory tests were repeated by following ring tests using Covax Reagent. All the results obtained were compared with permissible limits laid by WHO-UNEP-1996. The results obtained are given in Table-1.

Table-1: Bacteriological Analysis Data At Different Sites

Sample Description	Coliforms/100ml	Thermo-tolerant Coliforms/100ml	E. Coli /100ml
BhaginiNiveditaVidyalaya(B.N.V)	00	00	00
Residene beside B.N Vidyalaya	More than 16	16	16
ZillaParishad School,	03	00	03
Residence beside Z. P school	09	06	06

Mainstream Of Gram Panchayat Office	09	06	06
State Bank Of India	00	00	00
Motilal Kothari Vidyalaya	More than 16	More than 16	16
Police Station Office	03	00	00
Hotel at S. T stand	More than 16	More than 16	06
RasiklalDhariwalCollegePharmacy	00	00	00

Among these ten sites at only 5 sites RWH was done. The water supply at MK Vidyalaya was suggested to stop immediately as students of the school used to drink it every day. Immediate cleaning of the water tank was done followed by standard dosing of chlorination to purify the water. At two residences and at Gram Panchayat office also immediate actions were taken. Tanker water users were also educated and asked to do chlorination immediately.

It is not simply the storage of water that is important, but it is also necessary to maintain its quality. Hence it is equally important to carry out qualitative and quantitative estimation of different physicochemical parameters such as color, temperature, turbidity, TDS, acidity, hardness, pH, sulfate, chloride, nitrates, alkalinity used for testing of water quality. In the present study, results obtained for physic-chemical studies carried out for harvested as well as non -harvested rain-water samples on the six different sites. Results obtained are as shown below in Table-2.

Table-2: Analytical Results for Physicochemical Studies

Test Parameter	Sample I	Sample II	Sample III	Sample IV	Sample V	Sample VI
Physical Appearance	Clear	Clear	Clear	Clear	Clear	Clear
Odour	No Smell	No Smell	No Smell	No Smell	No Smell	No Smell
Turbidity (NTU)	0.71	0.61	0.54	0.47	0.82	0.68
pH Value	7.88	7.67	7.50	7.66	8.01	7.60
Chlorides (mg/L)	180.0	140.0	170.0	140.0	230.0	130.0
Nitrates ppm	20.68	47.0	7.06	21.0	22.99	15.30
Sulphates , ppm	117.0	64.28	50.03	149.66	88.96	73.21
Alkalinity as $CaCO_3$	140.0	194.21	114.56	340.0	210.0	130.47
Total Hardness, ppm	120.0	246.32	80.0	350.10	245.00	130.0
Total Disssolved Solids,	410.0	510.0	395.0	460.20	644.0	490.50
Iron as Fe, mg/L	0.10	0.11	0.20	0.00	0.22	0.13
Fluorides	0.545	0.500	0.310	0.616	0.710	0.520

The Sample I is water sample from Police Station , Kada; Sample III is from Bore well at B.N .School, Kada while Sample VI is from Bore well Z. P. School, Kada. Sample II is taken from Gram Panchayat Office Kada, Tap Water; Sample IV is from a residence near Z. P. School while Sample V is from M. K. V School, Kada.

It can be seen that the bore-wells where RWH was done that is at Sample I, Sample III, and Sample VI, these sources gets diluted and disinfected naturally, while in Samples II, IV and V, are samples collected from sources where RWH was not done. Iron is the element which is most abundantly found in the earth's

crust. Rainwater dissolves iron as it infiltrates the soil as well as the underlying geological formations. Due to this, iron seeps into aquifers that serve as sources of groundwater for wells. It may cause trouble in domestic water supplies. Iron in concentrations is as low as 0.3 mg/L renders reddish brown color to the water. As such, its permissible level in drinking water is 0.3mg/L without any relaxation.

Table-3: BIS Specifications 10500:2012

Parameter	Desirable Limits	Permissible Limits
Odour	Agreeable	Agreeable
Turbidity, N.T.U	1.0	5.0
pH Value	6.5 – 8.5	No relaxation
Chlorides	250	1000
Nitrates	45	No relaxation
Sulphates	200	400
Total Hardness	200	600
Alkalinity	200	600
Total Dissolved Solids	500	2000
Iron	0.3	No relaxation
Fluoride	1.0	1.5

CONCLUSION

1. The researcher conducted interviews of the beneficiaries to ascertain the benefits of RWH or to get feedback on the project, the beneficiaries informed that the water level in their bore-wells has increased substantially and they are enjoying the results of RWH by getting ample of water till the month of March-May.
2. These bore-wells were providing water to the month of Dec- Jan only before carrying RWH project. After completion of Rain Water Harvesting project, these bore-wells provided water to the month of May. These people faced the scarcity of water in the month of May only. The researcher has not carried out scientific calculations for measuring the increase in water level as the data for previous years for water level was not available and people were using water brought from tankers.
3. It is found out that water gets naturally purified by effective means of Rain Water Harvesting as the Total Coliforms, which are main indicators of water contamination decreases to negligibility.
4. The pH of all water samples was found close to neutral. Alkalinity, Total Hardness. TDS in water samples where RWH was not done, showed higher ranges, which may be due to the concentration of dissolved rocks which is comparatively less in water samples where RWH was done.
5. Both fluoride and iron contents are found within permissible limits in almost all water samples except MKV School and Water sample at the restaurant has shown slightly on a higher level.

From the results, it can be concluded that Rain Water Harvesting is one of the effective primary micro-catchment methods which proves to be highly beneficial to mankind and is a natural, easiest and affordable way to overcome water crisis. Although, more studies are needed, RWH should be made mandatory for every building during its construction.

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