A Critical Review of Quality of Rainwater Harvesting System

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Abstract*: *Water scarcity is a vital problem in the growth of many countries. Increasing water demand because of urbanization and industrial development and increase in agricultural fields is inescapable. Surface and ground water are rapidly utilized. Rain water harvesting is also a crucial strategy to catching, collecting as well as storing rain water during the downpour that can be helpful to recharge ground water. Rain water will be used for the demand of water supply as well as it helps to increase the quality as well as quantity of water. This paper discusses existing information on the water quality of storm water services on the roof. Various factors influencing the physicochemical as well as microbiological consistency of harvested water are explained. Most research indicates that rainwater is severely polluted by heavy metals, trace organisms, or even pathogenic organisms until extra precautions are followed during collection as well as treatment. Most of the contamination required appropriate treatment techniques, including filtration, chlorination and disinfection to enhance the quality of rain water.

Proper management of rainwater gathered will be required to make the rainwater extracted safe for consumption. Various previous studies have shown the importance of Quality of water and its effect on human health.

Keywords*: *Rain water harvesting, Quality of water, Roof runoff, rain water treatment.

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1. INTRODUCTION

On the earth 70 percent of it is water but only 3 percent of water is available for humans. Out of 3 percent only 1 percent is fresh water, the rest 2 percent is in the form of ice and glaciers. 1 percent water is renewed by rainfall to be available for human use. [1]. Population development, industrialization and the unreliability of sources of water are factors leading to the challenge of water availability for households. Globally, climate change also aggravates water shortages, reducing river flows and amounts of reservoir capacity. [2, 3].

During the monsoon season, rain water collection improves the rain water over and above storage tanks for recharging ground water. Rain water obtained from the roof does not need any significant treatment in order to be processed in tanks for supply of potable water. This could be used as make- up water for the drinking water source, as it will reduce pumping time. [4]. The use of rain water, which is among the inexpensive alternatives since it does not actually require advanced developments for its installation as well as service, becomes the way to minimize the burden on any use of drinking purposes. [5]. Integrated to decreased surface water, such factors improve water shortages in urban environments, mainly in developing countries. This decline in ground water rainfall patterns is also another aggravating circumstance. [6].

Rain water harvesting may play a significant role in increasing water Quality as well as minimizing the effect on the environment. On several options to save water and reuse it. [7]. Potable water savings, the prevention of floods in urban catchments, and the elimination of nitrogen loads on rivers are the results of RWHS. Furthermore, relative to other collection systems, RWHS does have other benefits in the form of a lower population density and more efficient use of resources since less pumping from source to user is needed. [8]. It's been well known that RWHS is incapable of growing an urban water supply's highest water needs. [9]. The rainwater collection method has been used as a water supply in most developing countries to higher water resources due to warmer climate. [10].

Implementing the objective of ensuring water supply would be a concern for many developed countries, especially to population expansion and predicted environmental issues. [11].

In several nations, such as the USA [12], China [13], Australia [14]; [15], Brazil [16]; [17], Canada [18], France [19], UK [20]; [21], rain water irrigation systems have been introduced to support the growing demand for water. Integrating the rain water collection system with current traditional water supply schemes would help increase production and add to water supply conservation. [22].

Water conservation is an ancient approach of capturing rainwater mostly from buildings as well as other floors and depositing it for further later use. Urbanization, scarcity of water, deteriorating rainwater systems, and sustainable development have all sparked an increasing trend in the technique that has grown prevalent in several nations. The quality of storm water, if used during non-potable and fresh water purposes, is one of the most crucial issues. The majority of research demonstrates that the quality of water acquired in a RWH system is influenced by a variety of aspects including: Meteorological conditions, Catchment material, Environmental conditions and suitable treatments.

2. QUALITY ASSESSMENT OF RAIN WATER

A. MICROBIAL QUALITY OF RAINWATER

The microbiological quality of rain water obtained consists of several components. This includes roof material consistency and roof pollution. Usually, the bacteriological content of rainwater by metallic rooftop is higher than most other types of roofs [23, 24, 25].Numerous toxins, like heavy-metals with trace-organic compounds in roof-runoff affect the physico-chemical as well as biochemical quality of the captured water. Multiple aspects including such rooftop infiltration surface water, roof material, rainfall intensity, the dry period pending a rainfall occurrence, and contamination proximity decide the physical- chemical quality including its rainfall obtained, whereas bioactivity, roof material as well as dryness duration may be critical function in quality assessment [26]. Actually illustrate that rainwater collection schemes may not always follow the microbiological potable safety regulations. The regular occurrence of fecal contamination is already identified to a variety of sources, and so most water contamination has been of organism generators since the fecal coliform/fecal pathogenic organisms proportion is around unity [27]. Aero-monas as well as the different variable species in building's roof rain water were found to have a favorable relationship in a latest sample mostly from villages of New Zealand [28].

B. HEAVY METALS AND TRACE ORGANICS

Industrial and educational numbers were slightly higher than public trace metals [29]. The relative contributions of environmental precipitation as well as roofing compounds to heavy metal emissions from roofs of buildings have been attempted to be determined. While copper concentrations frequently exceeded quality standards of fresh water. Differences in copper concentrations between rainwater collected and storm water, as well as between rainfalls in each of the 4 roof types tested, were observed to be systematic [30]. Zinc as well as copper were found to be the most significant violations of water quality regulations [30]. Some tests have indicated the existence of cadmium and lead. Debris from such a polyester roof [31], slate roof [32], galvanized iron roof [28] being found to contain lead. All above proportions did not improve instead with runoff distance for a polyester roof, but it was for such a tile roof. Both organic compounds were present in inorganic forms on a gravel flooring. Acid rain is commonly consistent with elevated metal concentrations in rainfall as well as low pH has been correlated with larger lead contamination [28]. Copper in precipitation improved for the patina age, and also the extracted copper existed as moist cupric ion, another very bio - available metal form, according to their findings. The overall absorption of copper is around 0.9 – 9.7 mg/l. Zinc content of recent tops is considered to be relatively greater than those of older rooftops [30]. Petroleum hydrocarbons including such toluene were shown to be larger in drainage from such a tar paper floor [33]. For such a polyester rooftop, organic substances became high, and even some organic contaminants turned up in large quantities during the 1st minute as well as the first 10 millimeter of drainage range [31]. They have discovered that while a polyester roof serves as just a pesticides conveyor, gravel as well as tile roofs hold pesticides. While there were some occasions in which a roof acted as a drain, its position as an origin of contamination predominated. Higher amounts of pesticides in the organo [34]-chlorine (aldrine and lindane), organo-nitrogen and sometimes organo-phosphorus types (propazine, Malathion, fenitrothion, etc.) have been identified only from metal sheets [33].

Table-1 Quality of Rain water harvesting [26].

References or Authors and year	**Location/ Study Area**	**Sample Capture from**	**No. of samples studied**	**Tested parameters**	**Concentrations**	**Salient findings**

[27]	Thailand	Roof-catchments as well as point of consumption	709	Faecal coli-forms, faecal strepto-cocci	-	The WHO requirements were defined in 76 percent of the samples.
[29]	Maryland, USA	Roof-catchment	38	Cu, Zn, Pb, Cd	Concentration: zinc 100 mg/l in certain samples. Residential, industrial, and educational buildings have mean Zn concentrations of 100, 1,100, and 1,100 mg/l, individually.	Metal levels in educational and industrial buildings were larger than in homes.
[32]	Marais, Paris	Roof-catchment	31	Cd, Cu, Pb, Zn	Median: Zn 29 998 mg/l, Pb 392 mg/l	Zn roofs have high Zn and Cd concentrations, while slate roofs have high Pb concentrations.
[33]	Gdansk, Poland.	Roof catchment	45	Petroleum hydrocarbons, pesticides	The amounts of organ nitrogen as well as organo-phosphorus range in 15.26 mg/l for sheet metal to zero to asbestos. In the case of organ chlorine, 4.58 mg/l from sheet metal to zero in tar paper.	Many as half of the tests are poisonous, with resistance levels of more than 20%. Toxicity was only weakly linked to pesticide amounts of organo-nitrogen and sometimes organo-phosphorus.

[24]	New Delhi, India	Roof-runoff	54	Faecal coli-forms, Heterotrophic-plate count, Total coli-forms, Faecal strepto-cocci	-	There are also indicators of microorganisms growing. Rough surfaces had further toxins. 13 per cent complied with WHO guidelines for all predictor microbes and 25–30 percent followed relaxing standards.
[31]	Tuffeon wies, Zurich	Roof catchment	14	Cu, Pb, Cr, Zn, Fe, Cd, Mn	Concentration of (mg/l) at the 0.2 mm of runoff depth: Pb 2.7–41, Cr 0.6–1.7, Cu 18–842, Cd 0.1–0.4, Fe 90–415, Zn 9–115	Fe as well as Pb have met the safety standard for drinking water. Cu, Cd and Pb in slightly reactive form. Heavy metals remained on the gravel roof.
[31]	Zurich, Switzerland	Roof runoff	14	Pesticides	-	For a few cases, pesticide concentration greater than 100 mg/l on tile roofs.

3. TREATMENT OF RAINWATER HARVESTING

The basic prerequisite for developed areas is a cost-effective, feasible care process. A first gain mostly in the rainwater quality can be obtained by discontinuation of this first flush of such a rain case, e.g. the first wash-water diversion. They are easy to mount, work efficiently but come in a choice of various sizes to fit various specifications. In order to improve the efficiency of storm water, they decrease the cleaning of the tank. A number of mitigation methods have also been implemented to reduce the contamination that occurs as rain water comes into contact with a flooring material, in order to increase the consistency of rainwater. The first-flush device, this is used to extract the initial 0.8 to 3.5 millimeter for runoff from storing within a cistern with rain water and has been successful in Australia, is once an example of a treating technique [35]. The first-flush effect, which has been recorded in the literature and states that the accumulation of toxins declines rapidly within the first several millimeters of rainfall, is just the basis for such instruments. While a variety of chemicals, such as retained particles, PAHs, organic-matter, even trace-metals, a certain pattern was already identified [23]; [36]; [37]; [38]; [39].

Chlorination is the extremely popular and straightforward method of disinfection. Many microorganisms may be deactivated with chlorine, and it is reasonably

inexpensive. Since chlorine can combine with organic substance which has accumulated at the bottom of the tanks as well as form undesirable by-products, chlorination must be added just after collected water has been removed mostly from storage tank [40].Chlorination can achieve a free chlorine concentration of 0.4 to 0.5 mg/L and may be accomplished with tablets of chlorine and sometimes chlorine in form of gas. Some parasitic organisms have demonstrated tolerance to small dosage of chlorine, which is a limitation of chlorination disinfection. Slow sand filtration is a low-cost way to increase water's microbiological consistency [41]; [42].

After collection of rain water in cistern, particle filtered through UV disinfection are major ways where the rain water could be purify [43] Investigated efficiency of metal-membrane filters (equivalent by polymeric-membrane filters) with UV-disinfection over harvested from roof storm water in a sample. The Korean analysis showed a 50% decrease in the amount of total-coliforms for further rain water sampling handled with UV lamps and a low strength of IUVA 5.4W/m2 [43].

Filtration further reduced the overall large quantity of coliforms only removing through the surface of the membrane. In 5 mm & 1 mm for metal filter media, removing efficiency was either 78 percent as well as 98 percent, respectively. The 5 mm with 1 mm metal-membrane filters, by comparison with eliminating microbial species, eliminated 80 percent as well as 95 percent of the particles present throughout the rainwater, respectively [43]. In the study, at sub-boiling water temperatures, Escherichia coli was also inactivated in another sample. In a lab environment, [44] found a nearly 5 log decrease in the E.-coli concentrations while rain water had held at 60 degrees Celsius to 5 minutes.

Filtration procedures are often used to remove toxic chemicals from rainwater. Particle-bound molecules make up a portion of these compounds. Filtration is used to isolate these suspended solids. Hence a rapid sand filter is perhaps the most general kind of filter. Water flows vertically through any sand, which is frequently filled in anthracite coal and activated carbon [43]. Chemical compounds that contribute directly to taste and even odour are removed by the surface coat since the gaps areas respectively retained particles are higher than void space between the smaller retained particles, easy filtration is always effective. Most of the particles migrate through surface layers yet are caught in pore spaces as well as attach to sand particles & biofilms about the path via the filter [43]. Effective filtration further improves the buffer depth. This filtering property is the secret to its operation: when this upper surface of sand were to eliminate all the particles, the filter will easily clog. Metal membrane filters (1 mm as well as 5 mm) also tend to be useful for clearing rainwater up to the utilization quality. Both ozone bubbles but also aeration mostly on the feed side is known to mitigate membrane fouling and also to remove the microorganism. The biggest flogging issue is the obstruction of pores [43].

Table-2 various water Treatment Methods [45]

Types of Treatment	**Sub-division**	**Advantage**	**Disadvantage**
Filtration	Activated carbon filter	• Fe and H_2S may be removed • May improve Taste • It can remove odour but also colors	• Viruses and bacteria are not removed
	Sand Filter	• Effectively improves Microbiological but also Physicochemical qualities	• Viruses are impossible to kill • Oxygen Availability, time and temperature all affect performance • A large area is needed
	Membrane filter	• Can be removed from bacteria as well as sediment	• Cannot Remove viruses • Pre-filtration is required

	Reverse-osmosis filter	• efficient at reducing micro-organisms and residual chemicals from water	• Cost effective • Additional draining arrangements as well as power supplies are required • Pre-filtering is required.
Chlorination Disinfection	_	• Bacteria, Viruses as well as Giardia are all removed • Residual chlorine can help to keep the quality of water safe for longer	• Long-term intake of chlorinated water can be harmful to health • It is difficult to find out what dosage is right for you
Ozonation disinfection	_	• Taste of water is little affected • Parasites, bacteria, and some other pathogens are killed • Produce less amount of chemical by-products	• While less by-products is made they have the potential to be carcinogenic • There is no residual left. • Safe for using.
UV disinfection	_	• Protozoa, viruses, as well as bacteria are all effectively removed • Less Maintenance is required	• Before filtration necessary to proper penetration of light • Required supply of power

Based on literature review, above a variety of techniques, including slow sand filtration [46], membrane filtration [43], disinfection [47], adsorption [48]; [49], ozonation [50]. It is debatable to suggest that combining sand filtration with chlorination to enhance the water quality but also storage period of captured rain water at a low cost?

4. CONCLUSIONS

The present study highlighted contamination processes as well as characteristics of the reliability of rainfall and the related public health risks but also control measures. The review identified the possibility of pollution of storm-water by physicochemical and microbiological pollutants from origin to points of usage. Water quality is determined by the types of roof, the increase in the amount of runoff, and the proximity of emission sources. The efficiency of the roof may be influenced by the roof top quality material as well as any dry periods.

More studies are required to determine the microbial risk identified with drinking water through rainwater collection systems in the residence. Poor storage as well as maintenance procedures would drastically decrease the efficiency. This highlights the importance of appropriate development as well as management approaches to keep potable roof-collected storm water sources secure. Increasing light exposure as well as routine washing of the rooftop surface are critical in reducing microbial pollution. To mitigate the risk of water pollution deterioration during this period, treated water should be properly disinfected. There are a variety of disinfection methods available, Chlorination is a common method that improves the microbial quality. Filtration processes are often used to remove chemical metals from rainwater.

Future research in developed countries should also concentrate in understanding the origin and origins of pollutants, determining the effects of various roofing materials and land use activities on the quality of rainfall.

The relation between the condition of roofing water from different roofing materials as well as disease outbreaks also conducts studies and focus on the proper treatment of rooftop water.

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