TREATMENT OF FIRST-FLUSH RAINWATER BY NATURAL LOW-COST ADSORBENTS USING MULTIMEDIA FILTER TECHNOLOGY

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Abstract: Rainwater harvesting technique can provide an alternative water source, demanding less treatment, depending on the end use. As in most cases, first flush rainwater is not being utilized and is discarded without use. So, this paper deals with the design of multimedia filter technology using natural adsorbents like Orange peel and Sugarcane bagasse for the treatment of first flush rainwater. Sieve analysis has also been done. The first-flush rainwater quality is tested before and after the filtration process respectively and removal efficiency for physical, chemical and biological parameters are analysed. The use of low cost and eco-friendly adsorbents has proved to be the best alternatives to the current expensive methods for removing organic and inorganic impurities from wastewater. Filtration technology is the simplest and low-cost treatment technology based on the principle of attached growth process. Treated water is used for Irrigation, toilet-flushing, gardening, fire fighting, etc. Different packing media are used as sugarcane bagasse, orange peel, sand, and gravel. The removal efficiencies of some of the parameters were found to be EC = 59.2%, TDS = 58.33%, Turbidity = 83.75%, Total Hardness = 57.27%, COD = 65.78% and BOD = 78.85%.

Keywords: Adsorption, Filtration, First-flush Rainwater, Multimedia Filter, Orange peel, Sugarcane bagasse.

Introduction: In recent years, urbanization and development had led to increasing the surface runoff flooding and runoff contamination [1]. Because of the scarcity of the clean water, treated rainwater potentially provides an alternative source for toilet – flushing, irrigation, gardening, etc. [2]. Rainwater Harvesting (RWH) systems are increasingly becoming an integral part of the sustainable storm water management 'toolkit' [3]. Inadequate supplies and insufficient treatment are the two major water problems in developing nations, means that we must search for an alternative approaches, including the use of low–cost, low–energy water treatment technologies, keeping in mind the financial and technical limitations of the poor who live in semi-urban or rural areas [4]. Rooftop rainwater Harvesting (RWH) is seen as an alternative source of water, especially in urban and developing countries [4]. In some semi-arid regions of the world, rainwater harvesting has been promoted for a long time as a useful technology. For example, in 50% of the Tanzania area, people completely rely on rainwater for their survival [6]. A simple rooftop RWH system consists of its catchment area, a treatment facility, a storage tank, a supply facility and piping [5]. The quality of harvested rainwater has found to be dependent both on the type of roof material and environmental conditions i.e., the local climate and atmospheric pollution. The pollution from the rooftop is classified as the External or Internal source of pollution. External sources include air pollutants and organic substances from human activity, leaves, and bird waste. The main cause of pathogenic bacteria on the rooftop is from faeces of birds and mammals that have access to the rooftop. The internal source of pollution occurs from the roofing material itself [7]. Rainfall or precipitation is the main process by which trace gasses and aerosols are combined from the atmosphere and fall onto the Earth's surface. They play a major role in the chemistry of rainwater by in cloud and below cloud scavenging process. As a result, the following chemical species are found in rainwater: ammonia, sodium, potassium, calcium, magnesium, hydrogen, sulphate, chloride, nitrate, bicarbonates and carbonate ion. Among this hydrogen ion concentration is very important for acid rain assessment. It is well known that most RWH systems installed "the first-flush phenomenon"- the concentration is extremely high in the first minutes of a rain event, and decrease later towards a constant value [8]. The first-flush effect is caused by one or a combination of following three processes: [9]

1. Matter deposited on the roof during the dry period.
2. Weathering and corrosion products of roof cover are washed off.
3. The concentration of rainwater particles containing aerosols and gasses.

Among various available technologies for water treatment, 'adsorption' process is considered better as compared to other methods because of easy operation and simplicity of design. First-flush rainwater is generally not treated and utilized, so this paper provides the treatment of first-flush rainwater using natural adsorbents. Adsorption is one of the established unit operations used for the treatment of contaminated and polluted water i.e., raw water and/or wastewater. The most common used adsorbent is activated carbon. Due to its high cost and considering the large quantity of effluent produced by various industries, researchers are

turning toward the use of alternative adsorbents, also called non-conventional low-cost adsorbents [10]. Nowadays efforts have been made to use cheap and available agricultural wastes/Natural products such as coconut shell, sugarcane bagasse, orange peel, peanut husk, rice husk, jackfruit, pecan shells, maize cob, apple waste, and sawdust as adsorbents to remove physical, chemical and heavy metals from the water [11].Here we are using sugarcane bagasse and orange peel as adsorbents in our filter media for the treatment of first-flush rainwater. The chemical constituents of orange peel are alkaloids, saponins, terpenes, resins, flavonoids, phenols, tannins and sugars [12]. The major composition of sugarcane bagasse contains cellulose 32% to 48%, hemicellulose 19% to 24% and lignin 23% to 32% [13]. The main advantage of filtration process is that they maintain high concentrations of micro-organisms which further results in high removal rate. Filtration technology is the low-cost treatment technology based on the physical process to treat contaminants like colour, odour, turbidity, hardness, COD, BOD and suspended solid etc. [14].

Aims and Objectives: Designing the low-cost multimedia sand filter model and treatment of first-flush rainwater by filtration process using low-cost natural adsorbents and study the performance of multimedia filter with different packing media such as Orange peel, sugarcane bagasse, coarse aggregates, fine aggregates, and sand was the objective of the experimental study. The removal efficiency of physical and chemical parameters was studied. The treated water used for Irrigation, toilet-flushing, car washing, gardening, fire fighting, etc.

Experimental work: Study Area: Hamirpur is one of the districts of Himachal Pradesh. It is spread over an area of 1118 sq. km. It is also known as Martyr's land. Hamirpur is situated between the latitude of $31^{o}25'$N to $31^{o}52'$N and longitude between $76^{o}18'$E to $76^{o}44'$E and the mean sea level of 785 m. It is not a typical hilly area. As during the rainy season there is a problem of water supply in all the hostels of NIT Hamirpur due to silt factor during the pumping. So, the study was carried out on the first-flush of Himgiri Hostel, NIT Hamirpur.

Fig. 1 (Orange peel ad Sugarcane bagasse).

Materials and Methods: A collection of Adsorbents: The adsorbent used for this study are sugarcane bagasse, orange peel and sand was collected from the local market.

Preparation of Adsorbent:

The adsorbent of Sugarcane Bagasse (SB): The sugarcane bagasse was soaked in 0.1M HCl solution for 18 hours and then washed with distilled water to ensure complete removal of all the dirt particles, lignin and colouring materials present. After that, the bagasse was dried in an oven at 120-130^{o}C and ground in a home mixer.

The adsorbent of Orange Peel (OP): The collected peels were cut into small pieces, washed with distilled water to remove dirt and suspended impurities and then dried for 48 hours in an oven at 100^{o}C to remove the moisture content from the peels fig. 2(b). After the drying process, the peels were removed from the oven and kept in the desiccators for 30 minutes. The desiccator contains calcium chloride (CaCl2) which is used to cool and maintain a dry environment and then the peels are ground to fine powder fig. 2(a).

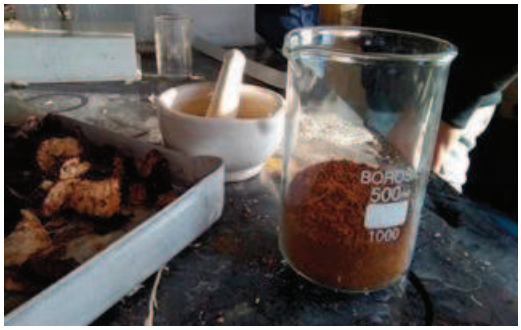


Fig 2(a)

Fig2(b).

Designing of filter media: Filtration Model: The model of the multimedia filter of plastic material was designed for a family according to the census of India, 2011 & BIS then developed. The model consists of two cylindrical bucket place one over the other. The depth of each bucket is approximately 40cm and diameter is about 17 cm. So, the total height of the filter medium is 80cm. The upper bucket has a compartment of filter medium where various filtering

materials were placed and the lower bucket is placed for the collection of filtered rainwater.

Analysis and Working of Model: The first-flush rainwater was collected from various roof discharges from the buildings of the NIT Hamirpur campus. The collected rainwater is passed through the filter media and it flows down in a flow regime sequence. From the figure no. 3 it can easily be seen that the compartments were packed with Sugarcane Bagasse, Orange Peel extracts, Sand and Gravel.

The treated water is collected than in the lower bucket.

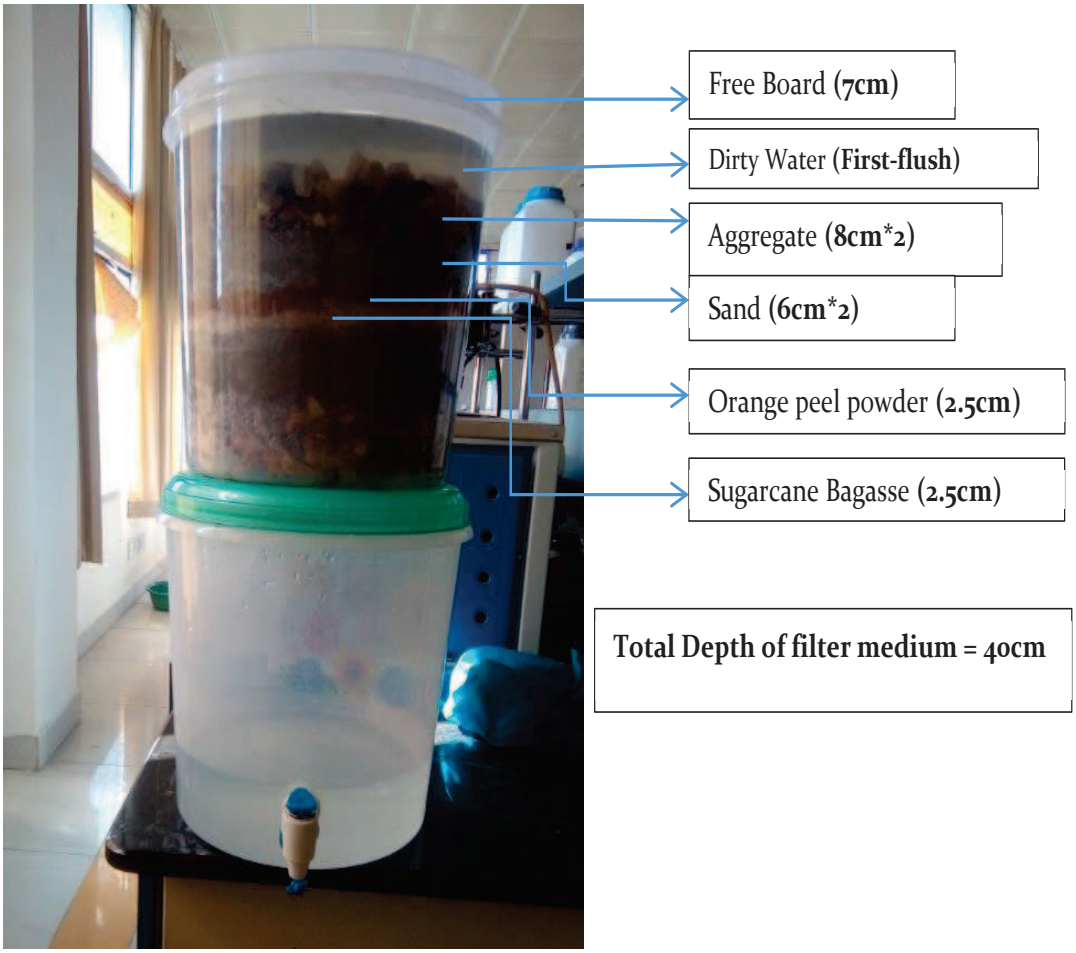
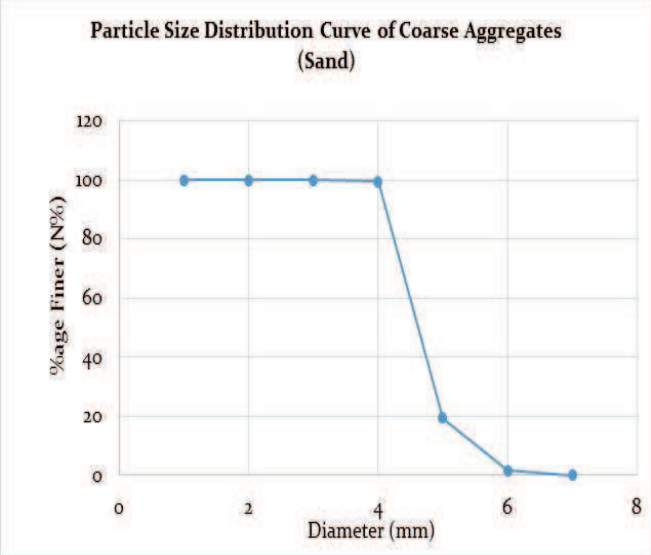


Fig 3: Designed Filter

Sieve Analysis:

Table No .1: Particle Size Distribution Curves of Course Aggregates (SAND)

Sieve	Weight Retained	%age weight	Cumulative	%N finer
4.75	0	0	0	100
2.36	0	0	0	100
1.18	0	0	0	100
0.6	13	0.65	0.65	99.35
0.3	1600	80	80.65	19.35
0.15	355	17.75	98.4	1.6
PAN	32	1.6	100	0
	2000			



The effective size (D_{10}) = 0.221

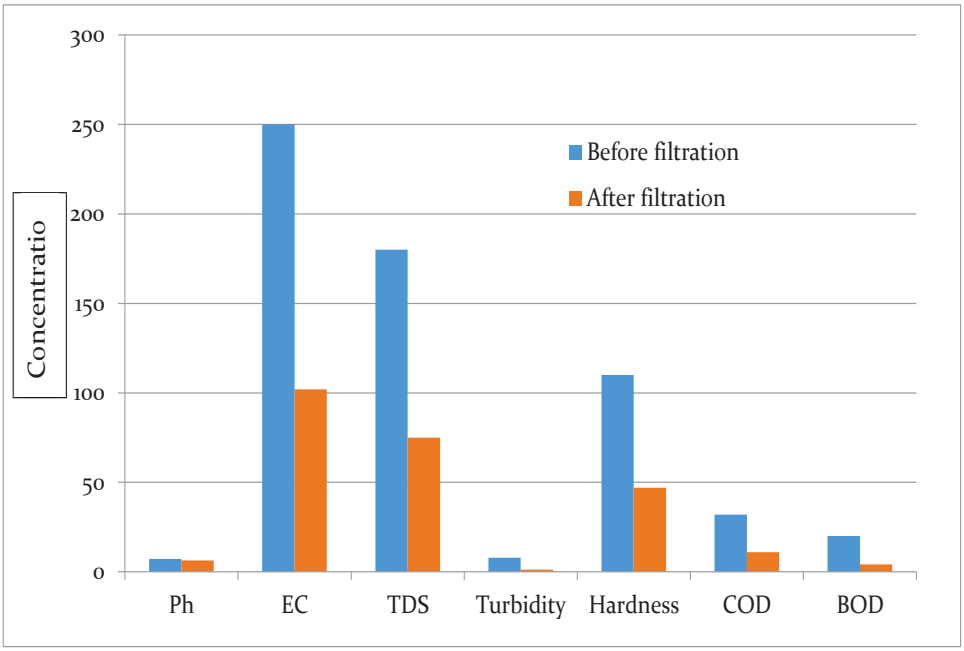
30% finer particles and 70% particles are coarser than D_{30} = 0.3399
60% finer particles and 40% particles are coarser than D_{60} = 0.4524
The uniformity coefficient (C_u) = 2.05.

Results and discussion: It was observed that the adsorbent materials such as Sugarcane Bagasse and Orange peel may prove to be more efficient in improving the effluent quality in terms of its physical and chemical content. It was also observed that the experimental filter model will significantly assist in the removal of COD, BOD, TDS, Turbidity, and Total hardness, EC, Chloride, and Colour. Hence, the result of the present investigation says that this filter is found to be an effective adsorbent filter for the removal of impurities from the rooftop first-flush rainwater and the treated water is used for Irrigation, Toilet flushing, Car washing, fire fighting, gardening, etc. with proper care and maintenance. From the table no. 2, it was observed that the removal efficiencies of some of the parameters were found to be EC = 59.2%, TDS = 58.33%, Turbidity = 83.75%, Total Hardness = 57.27%, COD = 65.78% and BOD = 78.85%.

Table No 2: Physio-chemical parameters of the first flush

S.No.	Parameters	Units	Before Filtration	After Filtration
1	pH	-	7.2	6.32
2	Electrical Conductivity	µs/cm	250	102
3	TDS[a]	ppm	180	75
4	Turbidity	NTU	8	1.3
5	Total Hardness	ppm	110	47
6	Total Alkalinity	ppm	65	31.7
7	COD[b]	mg/l	32	10.95
8	BOD[c]	mg/l	20	4.23
9	Nitrate	ppm	2	1.7
10	Colour	-	0.3434 (gray)	0.0095 (light)
11	Chloride	ppm	82.56	50
12	Fluoride	ppm	0	0
13	MPN[d]	MPN/100mL	5.5	3.6

TDS[a] Total Dissolved Solids, COD[b] Chemical Oxygen Demand, BOD[c] Biochemical Oxygen Demand MPN[d] Most Probable Number.



Conclusion: Based on the results of this study, it can be concluded that Sugarcane bagasse and Orange peel have good adsorbing properties and this filter had given excellent results and significantly assist in the removal of pH, EC, TDS, Turbidity, Hardness, COD and BOD. So, it can also be considered as efficient pre-treatment process for wastewater treatment subsequently which may enhance the performance of the treatment system.

As in the above experiment, adsorbent with very good adsorbing properties like Activated Carbon is not used which is also an expensive material and still we are getting optimum results by using natural adsorbents. So, at present, we can adopt of using low-cost, energy efficient and environment-friendly natural adsorbents in place of expensive ones.

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